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WHAT DOES EINSTEIN MEAN?[1]

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I AM not sure that I shall fully succeed in explaining during this hour what relativity is, but I shall be satisfied if I succeed in at least removing some of the prejudices which have arisen in connection with this question. Relativity is so simple that the greatest difficulty in understanding it lies in getting rid of one's prejudices. It is really remarkable that Einstein, who is certainly the most popular scientist in the world, is the author of the most unpopular theory in the world. I think a greater harmony should prevail in the popular mind between the man and his work.

One of the common prejudices concerning the theory of relativity is the idea that according to it everything is relative. Nothing could be more incorrect than this assumption. The theory of Einstein states that many things, many notions, many qualities which we thought absolute are actually relative, but on the other hand it destroys the old absolutes only to build up new ones. It could be called, with better right perhaps, the theory of the absolute and not the theory of relativity. It introduces relative quantities only in order to build up absolute quantities out of them and to build up rules for connecting them which will be absolute and which will express physical laws. Maybe if the theory of relativity were called the theory of the absolute it would not appeal so much to the present sophisticated generation, and there would be less talk about it.

Another prejudice is the idea that the theory of relativity was entirely created by Einstein. It was prepared for by the work of Newton. The relativity of space was incorporated in Newton's work; Einstein extended this so as to include the relativity of time.

In his celebrated "Principia" Newton started by saying that space is absolute and that space is at rest: also, he added that time is absolute and flowing uniformly without any connection with other events. Let us leave time alone for a while, and consider what

[1] Address before the Minnesota Chapter of Sigma Xi.

Newton meant when he said that space is absolute and at rest.

I have heard that Ibsen was asked once as to what he meant by one of his plays, and he answered that when he wrote it only God and himself knew what he meant: but since then he had forgotten! I think Newton would say the same thing about his absolute space which is at rest, because from the results established by Newton himself it followed that it is physically impossible to discover and furthermore to determine what this "rest" meant. If some frame of reference is supposed to be at rest, and then another frame of reference is introduced which moves uniformly and in a straight line with respect to the first, then all the events will take place in exactly the same way with respect to the second "moving" frame as with respect to the first, which was supposed to be at rest, and therefore, so far as we can judge from physical phenomena, there is no difference whatever between the two systems of reference—both of them could, with equal right, be supposed to be at rest.

This statement expresses an experience which is very familiar to all who have had the opportunity of riding in a car, ship or train. You feel just as comfortable on a uniformly moving train or ship as you do in a room in a house. One does not notice the uniform motion. All events that happen on a uniformly moving car will take place in exactly the same manner as they take place with respect to the earth, and therefore we do not have any reason to say the earth is at rest and the car is moving.

The same result can be derived mathematically from the fundamental laws of motion established by Newton, thus disproving his original assertion that one can talk about an absolute space that is at rest. The first relativistic idea which we have to introduce is the relativity of uniform rectilinear motion. Given two systems moving with respect to each other uniformly and in a straight line, either of them can be considered as being at rest. From this relativity of motion, or more exactly of uniform motion, there follows the relativity of distances between points in space, so far, at least, as these points refer to events taking place at *different times*.

Let us speak more concretely. Suppose you are riding on a train and let us say are walking forward to the diner: you start at one moment and you arrive a few minutes later at the diner. What is the distance you have moved? It depends on how you measure it. If you measure it relative to the train it will be a rather short distance, perhaps 200 or 500 feet. If you measure the distance traveled with respect to the earth it would be an entirely different quantity, which depends upon the speed of the train. It is not necessary, however, to confine yourselves to the earth: you could take into account the motion of the earth in space. You could, for example, refer the motion of the earth to a frame of reference which is fixed at the center of gravity of the solar system, and then it would turn out that the distance you had moved was not 500 feet or the few miles that the train moved during this time with respect to the earth, but it was perhaps a few hundred or a few thousand miles, since the earth has moved with respect to this frame of reference fixed at the center of gravity of the solar system. And there is also no reason to use that particular system of reference. You could refer the motion of the solar system to any other coordinate system, and then it would turn out that the distance through which you moved was perfectly indefinite: it may have been 100 yards, or 100 miles or a million miles.

Now, this indefiniteness is the result of the fact that one can not define in an unambiguous way a point in empty space. It can be defined only with reference to some coordinate system. If you take two coordinate systems which move with respect to each other, then the distance between the point from which you started and the point to which you have arrived will be different for the two systems. Take, for example, a coordinate system which is moving with you. With respect to this system you will always be at rest, the distance traveled being in this case zero.

So the distance between two points is a perfectly relative quantity, at least so far as these two points relate to events corresponding to different instants of time. You can say, for example, that I have been staying at the same place from the beginning of my talk, which will be true if you consider the room and earth at rest. If you take into account the motion of the earth with respect to the center of gravity of the solar system, all of us have traveled quite a long distance during the ten minutes that I have been talking.

So you see, if uniform motion is a relative motion, then distance in space is also relative or, rather, indefinite. To this principle, however, an important amendment would be made by one adept in the old Newtonian theory, namely: That it is true if you consider the distance between points referring to events which take place at ***different times, not simultaneously***. The distance between two points, considered at the same instant of time, was assumed to be absolute, *i.e.*, independent of the choice of the coordinate system which was supposed to be at rest. The definition of "rest" would be immaterial in this case, because so long as the notion of simultaneity is considered as absolute, *i.e.*, independent of the definition of rest or motion, the latter can not affect our estimate of the

distance between two points visualized at the same time, the distance traveled by ourselves (or our system of reference) in no time being zero.

Here, then, I must warn you against a misunderstanding. When I am talking about the distance between two objects, I am thinking of the points of space with which these two objects coincide at their respective instants of time. When I am thus thinking of two objects at the same instant of time, then the distance between these two objects or the points of space which they occupy at the same instant of time will be independent according to Newton's theory of which coordinate system we assume to be at rest. So you see that the distance between two points is relative so far as they refer to non-simultaneous events, but it is absolute if they refer to simultaneous events.

This absolute character of the distance between points referring to simultaneous events was connected in the Newtonian theory with an absolute character of simultaneity. It was thought in the Newtonian theory that the notion of simultaneity was an absolute notion, that the notion of the interval of time between two events was unambiguous, in contradistinction to the notion of their distance in space. We thought that we could talk of a definite instant of time for the whole universe and could accordingly define a lapse of time as something definite for all the universe, irrespective of the coordinate system supposed to be at rest and to which we refer the places of all the events observed.

Thus the Newtonian theory was only semi-relativistic. It was relativistic with respect to space and distances in space so far as time was not concerned. Considering different points at the same instant of time one admitted that the distances between them also become absolute, because simultaneity was thought of as an absolute notion.

Now let us inquire why it was that the Newtonian theory admitted the possibility of defining an instant of time unambiguously for all the universe. I am sure that in this respect you all or most of you are the faithful followers of the Newtonian theory, and you probably also think there is no reason why you should not be able to define simultaneity in this absolute way. Now, if you think about it you will see that there was a physical reason which seemed to justify the assumption as to the possibility of defining simultaneity unambiguously (*i.e.*, independently of the coordinate system) for the whole world. This physical reason lies in the Newtonian conception of *force* or *action*. After all, how can you ascertain that two events taking place in different places, on different planets, for instance, are simultaneous? Only through some action coming from these two planets, and such action need not be the action of light: it is sufficient to assume that there is *some* action which can be transmitted from these two planets to the earth instantaneously. If such action existed we should theoretically be able to justify the notion of simultaneity as applied to events in different points of space.

Now, this was exactly the Newtonian and post-Newtonian notion about the transmission of forces through space. It was thought until the second half of the nineteenth century that forces could be transmitted instantaneously through space. We are so used to this notion that we don't even notice how it slips into our arguments. When a physicist talks about the force of interaction between two bodies, as determined by the relative position of these bodies, he fails even to mention that he thinks of the simultaneous position. He considers this simultaneity as something self-understood.

When he thinks, for instance, of the action which the earth experiences from the sun, the moon and the other planets, he usually assumes that this action depends upon the simultaneous position of all the other celestial bodies. He thus assumes that this action is propagated through all space instantaneously. It is this idea of the action at a distance which is propagated through space with infinite velocity that forms the basis of the assumption that simultaneity can be unambiguously defined. If you can theoretically imagine that the whole world can be embraced by some sort of action at a certain instant of time, then it is reasonable to talk of simultaneity as of something definite, which is independent of the choice of the frame of reference.

This idea of force, as propagated instantly through space, was developed with the Newtonian theory of gravitation as a model for forces of all other kinds. It was assumed that gravity was a force acting at a distance through empty space and transmitted with infinite velocity. Newton did not attempt to understand the nature of gravitation. He was satisfied with the recognition of the fundamental fact that gravitational forces were very similar to the forces of inertia connected with accelerated motion, both being proportional to the quantity which is defined as the mass of the body. Newton did not go beyond that, and further, in the Newtonian theory, the relativity of motion could not be generalized for non-uniform motion, *i.e.*, for motion which is connected with acceleration. It was supposed that acceleration, *i.e.*, the rate of change of velocity, was absolute and that relativity suffered a breakdown when applied to accelerated motion.

So you see that there was already a relativistic theory in the old physics created by Newton, but it was limited to space, it did not affect time, and fur-

ther it was limited to uniform motion. Now let us see what Einstein changed in this situation, and what was the basis of this change.

Einstein's theory did not come just like a "Deus ex machina," that is, completely unexpected. It was prepared for also by the development of physics in the second half of the nineteenth century. The fundamental results of this development consisted in the following facts (1) that all physical forces with the exception of gravity were reduced to electrical forces due to the invariable electrical charges of the elemental particles of matter, namely, the electrons and protons: and (2) that electrical forces are propagated through empty space with a finite velocity, whereas gravitational forces formerly were supposed to be transmitted through empty space with infinite velocity.

Now, this velocity with which all physical forces, so far as they are of electrical origin, are propagated is equal to the velocity of light. This coincidence is due to the simple reason that light is itself an electric phenomenon. In the present era of radio everybody knows that electrical vibrations generate electromagnetic forces, which are propagated through space in the form of "electro-magnetic waves" with the same speed as light, light vibrations differing from these radio vibrations in frequency or wave-length only. In the case of light, the wave-length is about one billion times shorter than in the case of radio waves, this difference being due to the minute dimensions of the atoms of matter which act like broadcasting stations in the case of light waves.

Therefore, the coincidence of the velocity of light with the velocity of propagation of electrical forces is simply the expression of the fact that light is one of the manifestations of electricity. If in the sequel I refer to this velocity as the velocity of light don't think that I am particularly stressing the optical side of physical phenomena.

Now, leaving aside for a while the forces of gravity, let us assume that all physical forces are propagated with a finite velocity—the velocity of light. What is the implication of this principle with respect to the definition of simultaneity? I mentioned before that the absolute character of simultaneity in Newton's theory was justified by the idea that one could embrace all space at a single instant of time by a physical force emanating from some material body. We now see that this is wrong. A physical force produced by any material body will spread in space with a finite velocity, and thus we lose our solid foundation when we speak of simultaneity as something absolute. This is the real physical basis for the "relativation," so to speak, of time.

The relativity of time follows from the impossibility of combining (by means of a physical action) what is separate in space. This principle could be the starting point of Einstein's theory. The path which is pursued by pioneers of scientific discovery is often more complicated than that which we can follow when we know the goal at which we must arrive. Einstein's path was more complicated than the one which I am indicating now—but let us continue on along this straightforward path. I shall at the conclusion of my lecture come back to the more sinuous path which was followed by Einstein, a path that was obstructed by a lot of prejudices which had to be destroyed.

There is no reason whatever, therefore, for assuming that events, separate in space, can be unified in time. There is no reason why the distance in time between two events taking place on different planets should be a perfectly definite quantity (*i.e.*, independent of the choice of the frame of reference supposed to be at rest). It may be just as indefinite as the distance between the points of space where these two planets were at the initial moment. It may be perfectly possible that the distance in time between two events taking place in Jupiter and Mars will appear different to an observer on the earth and one on another planet, if there were any such.

We are left now, so to say, with no criterion for the comparison of the intervals of time between two events as they must be determined by observers connected with two different systems. I must again warn you against a prejudice. It is sometimes admitted that the Einstein theory changes our ideas of time and space, time particularly, in a very fundamental way. Now, so far as we are considering events with reference to one particular frame (supposed to be at rest) relative to this room for instance or the earth, etc.—Einstein's theory does not change anything about our notions of time and space. Einstein's theory refers to the comparison of space and time intervals between given events as measured or determined with reference to different coordinate systems, which are moving uniformly with respect to each other and in a straight line, either of which may be assumed to be at rest.

Now, how shall we correlate the determinations of the time interval between two definite events by two observers, which are connected with different systems, moving with respect to each other? This question can be solved with the help of that very fundamental principle that is bringing us to the relativity of time, namely, the finite speed of the propagation of physical action. Here is a very delicate point which also gives rise to considerable confusion and which we must carefully elucidate.

Einstein's original (restricted) theory is based on the relativity of space so far as it depends upon the relativity of uniform rectilinear motion (*i.e.*, motion

with a constant velocity). Now, if motion is relative, then velocity must be relative also: the velocity with which something is moving, with which, for instance, force is propagated. This velocity should therefore be a quantity, which depends upon the choice of the system of reference supposed to be at rest. This seems perfectly natural: if motion is relative, velocity also is relative. We have just said on the other hand that physical actions are propagated through empty space with a definite velocity equal to that of light, *i.e.*, 187,000 miles per second. This velocity being relative, *i.e.*, being definable only with respect to some frame of reference supposed to be at rest, must at the same time be definite, *i.e.*, independent of the choice of this system. Now this looks like a contradiction. It seems to follow from the relativity of velocity that it also should be indefinite, *i.e.*, that its value should depend upon the choice of the "resting" frame of reference, and it seems impossible to make an exception in the case of any particular velocity, that of light, for example.

If it were so, however, the propagation of light and of physical forces in general would be a physical phenomenon which would enable us to discriminate between two systems of reference moving with respect to each other. If light were propagated in a different way with respect to two such systems then we certainly could say that the systems have different states of motion, *i.e.*, different velocities with respect to "empty space." That coordinate system with respect to which light is speeding with the same standard velocity 187,000 miles a second in all directions could be defined as being truly at rest and all the other systems with respect to which the velocity of light would be different, say in different directions, could be defined as truly moving. But the notions "true" motion, "true" rest, "true" velocity mean that rest, motion and velocity can be defined in an absolute sense with respect to empty state as the fundamental frame of reference supposed to be at rest. This would mean that one must give up the idea of relativity of motion.

But how can we give it up if space is actually void, if it does not contain anything? How can we speak of motion in an absolute sense? When Newton said space is absolute and at rest he did not seriously mean what he said, and we can not seriously mean to say that we can define the real or true velocity of a body with respect to empty space.

If therefore there is a relativity of motion then all velocities must be relative including of course the velocity of light, which, however, must be absolute in the sense that it must be the same whatever the system of reference, supposed to be at rest, with respect to which it is measured. Is it really a contradiction to assume that the velocity is relative in the sense that it can be defined only with respect to a coordinate system which is arbitrarily supposed to be at rest and that at the same time it is absolute in the sense that it is independent of the choice of this system? There is no contradiction between the two statements because the words "relative" (in the former) and "absolute" (in the latter) are used in entirely different senses. I should prefer, in order to escape confusion, to use two different words in the two cases. The term "relative" should be used with respect to velocity in the sense that velocity acquires a definite magnitude only with respect to some coordinate system which is assumed to be at rest: the velocity of light is no exception to this principle—it acquires a definite value only with respect to a system which is supposed to be at rest. As far, however, as any other velocity is concerned not only its definition but also its magnitude depends upon the choice of the "resting" coordinate system. Such velocities are therefore variable or indefinite. The velocity of light, or more exactly the velocity of propagation of all physical actions, enjoys an exceptional position in the sense that being relative it is at the same time definite, invariable or as they usually say in mathematics "invariant" (which does not mean that it is absolute). The invariant character of the velocity of light was established experimentally by Michelson, who tried without success to detect a difference in the velocity of propagation of light rays with respect to the earth (assumed to be moving in space) in different directions. Without by any means questioning the historic importance of Michelson's experiments we can say at present that these experiments were actually useless. If physicists were not prejudiced by the idea of the ether, a material medium in which light vibrations were supposed to be propagated, they would have come to the fundamental ideas of the theory without any experiments on the propagation of light relatively to the earth. For we know now, after the ether theory has been done away with, that if it turned out that light were propagated with different velocities in different directions with respect to the earth then there would be a meaning in talking about the absolute velocity of the earth with respect to empty space, but we have too much confidence in our intelligence to assume that such a notion has any physical meaning.

Let us now see what are the consequences of the two principles, that every velocity is relative, and that the velocity of light being relative is invariant (while all the other velocities do depend upon the choice of the coordinate system). Let us consider, for example, the propagation of a radio signal from one ship to another ship, the first one being anchored and the second moving with respect to it. Let us suppose that the anchored ship is sending a radio signal to the moving ship. What is the distance traveled by the signal and the time which it used to travel this

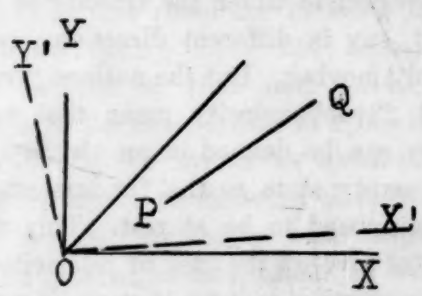
distance? The distance between the point of space from which the radio signal issued and the point of space where it arrived will depend upon the choice of the frame of reference which is supposed to be at rest. If this frame is connected with the anchored ship, then the point of arrival will be that point of space where the other ship is located at the moment of arrival, this point being displaced with respect to its position at the moment when the signal was emitted by the first ship by the distance the second ship is supposed to move while the signal is speeding towards it. If, on the other hand, the frame of reference is connected with the second ship, which is thus supposed to be at rest, while the anchored ship moves with the earth in the opposite direction, then the point of issuance will be that point of space where the anchored ship was at the moment of sending the signal, and the point of arrival can be identified with that point of space where the second ship was situated at the same moment, since it is assumed that it remains at rest. Thus the distance traveled by the radio signal must be different from the points of view of the first and of the second ship.

Now what about the time? Will the time elapsed between the sending of the signal and the receiving also depend upon the choice of the frame of reference supposed to be at rest? Not according to the old theory, which says that this time is a perfectly definite thing and that it must be the same for any reference system. This would imply that the velocity of propagation of the radio signal is indefinite—that it should depend upon the choice of the coordinate system supposed to be at rest.

Now we can say that this is not true. The velocity of light or radio waves must be the same with respect to any frame of reference. Since, on the other hand, the distance must be different for frames of reference moving with respect to each other we are forced to the conclusion that the interval of time between two definite events, between emission and receipt of radio signals in our example will be also different. We are thus forced to abandon the old dogma of the absoluteness and invariance of time. It would be considered as a big sacrifice if we persisted in thinking that we could define time in an absolute manner for the whole of space, that we could grasp the whole of space at a definite instant of time by means of some instantly transmitted physical action. Now we know that this was a wrong pretense, that what is separate in space can not be united in time, and there is therefore no obstacle whatever to giving up the idea that "duration," the time interval between two events, must be the same as estimated by two different observers moving with respect to each other. We shall willingly give it up, but how shall we get the correlation between the different times as determined by different observers? Now it can be easily seen that it is just this invariance of the velocity of light, for the sake of which the absoluteness of time has to be sacrificed, which enables one to establish the above correlation, *i.e.*, to compare the measurements of time by different observers. We can say that the intervals of time between two definite events—the issuance of the radio signal by the first ship, and its reception by the second as determined with respect to two different frames of reference—must stand in the same ratio as the corresponding distances, so that the ratio of the distance to the time, equal to the velocity of light, should be the same in both cases.

If we did not have this principle of the invariancy of the velocity of light we would have absolutely no way of comparing the determinations of time by different observers. It is only this principle that allows us to compare the estimations of time. An important point that should be mentioned here is that the theory of relativity allows the invariance of one velocity only (that of light). It would be impossible to build up a consistent theory of time and space if we had to insure the invariance of two or more different velocities. Thus Einstein's relativity theory is based on the unique character of the velocity of light.

The preceding results can be illustrated in a graphical way which I think will help one to understand them. We physicists are used to represent motion graphically. I hope all are acquanited with the principle of this representation. We draw two (usually) perpendicular axes OX and OY. Let distances be represented along the first and times along the second. A point P on this diagram represents an event



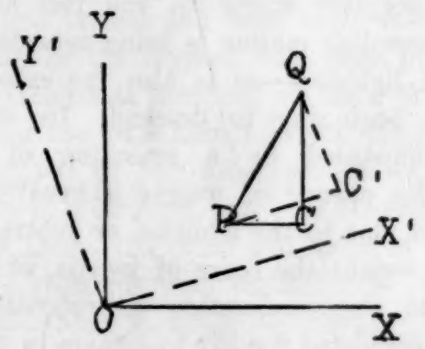
whose place is given by its distance along X and whose time is indicated by its distance along Y. The projections of the line PQ where the points P and Q represent two definite events represent the space and time distance between these events. A succession of points, *i.e.*, a line, represents motion. Straight line corresponds to uniform motion (taking place in a definite direction). A vertical line represents motion with zero velocity, *i.e.*, motion "in time" (without any change of position). So we can say a vertical line represents rest while an inclined line represents motion, the angle of inclination being a measure of the velocity of this motion.

Relativity of motion on this diagram can be inter-

preted as relativity of direction of inclination. We can just as well assume that the line OY is vertical, thus representing rest, while the line OY′ is inclined and thus represents a point in motion, or that OY′ is vertical and OY inclined and representing motion in the opposite direction. At the present time, in the twentieth century, it is very easy to realize this relativity of direction and of vertical direction in particular. The vertical direction is not the same for different points of the earth's surface, for New Yorkers or inhabitants of Paris. It is not a definite direction in space, as we imagined it to be in our childhood; it is a quite indefinite direction; so we can take any direction as vertical. Therefore the notion of inclination will also be relative. It depends upon what we take as vertical, and this relativity of inclination represents the relativity of motion or of velocity.

Now, let us take these two points, representing two events, P and Q. As has been mentioned above, the distance between the places of these two events and the distance between the times of these two events will be measured by the projections of the line PQ on the coordinate axis. They will thus be equal to PC and CQ, respectively, with respect to the coordinate system XOY (OY being the axis of time, *i.e.*, the "vertical" line representing rest).

Let us now take another system of coordinates X′OY′, with the time or "rest" axis represented by the "inclined" line OY′. The projections of PQ on this new axis will be represented by PC′ and C′Q: they will be different from PC and CQ and will thus represent a different distance in space and a different



interval of time. So far as distance in space is concerned, this is a perfectly natural thing we are already prepared to admit in the Newtonian theory. It is the difference in the estimation of time, as measured by CQ and C′Q, that constitutes a result which is characteristic of the new relativity theory.

But is there anything that remains invariant that does not change here as we pass from one set of coordinates to another that has the same value for both sets? This is the "space-time distance" PQ: It remains the same, whether we measure it in one set of coordinates or the other. We thus see that while the theory of relativity destroys the absolute character of notions which we thought absolute, it introduces instead new notions which are absolute, which do not depend upon the choice of the coordinate system which is supposed to be at rest.

I must now say a few words about the measurement of space distance between events assumed to be simultaneous, for instance, the length of a rod, moving parallel to its length. It is stated in popular presentations of relativity that such a rod should suffer a longitudinal contraction. Why should a thing contract when it is moving and how can one speak of a definite contraction if motion is relative? As a matter of fact, it does not contract at all. This belief in a contraction is a prejudice and misunderstanding. We must clearly understand what we mean when we talk about the length of a moving body. This length, *e.g.*, the length of the rod, is defined as the distance between that point of space at which one end of the rod was at a definite instant and that point of space where the other end of the rod was at the same instant. It is the distance between two different points in space with which the ends were supposed to coincide at the same instant that is to be regarded as the length of the rod.

Now what does "the same instant" mean? That is not a perfectly definite notion. What seems simultaneous in one frame of reference (supposed to be at rest) will not be simultaneous in another. The distance between two points of space where the ends of the rod were "at the same time" will be different, depending upon the choice of the coordinate system. If this distance turns out to be smaller in a frame of reference with respect to which the rod is moving than in a frame of reference with respect to which it is at rest, it does not mean a real contraction, but a perfectly natural variability of length, depending upon the relative character of the definition of simultaneity.

I can illustrate this by the following example: Suppose we want to measure the height of a tower. You could define this height by saying that it is equal to the distance from the bottom of the tower to the top. Now is this definition correct? It is certainly correct from our Minneapolis point of view, but let us be more broad-minded and let us give ourselves the point of view, say, of the New Yorker. We don't have to go to New York and look through a telescope at the tower, but we have simply to replace the Minneapolis vertical by the New York vertical. What will be the height then? It will not then be the distance from top to bottom—it will be the projection of this distance on the New York vertical line (which seems an inclined one from our point of view). So you see in Minneapolis the building has only a height, but with respect to New York it has a height which is smaller

and also a length which is equal to its projection on the horizontal plane at New York. Let us now cross the Atlantic and go to Moscow, say. Then the Moscow vertical will be parallel to the Minneapolis horizontal and the Moscow horizontal to the Minneapolis vertical. Thus from the Moscow point of view the building does not have any height at all, but only length. There is no mysticism about it, there is no trick to it, it is simply the result of the definition of height. Suppose a telegraph pole just fell to the earth. What would its height be? The distance from one end to the other would be the height when the pole was standing vertically: it will be the length when it is lying on the ground. Exactly the same can be said about the estimation of distance in time and distance in space. The former or "duration" can be compared to height, while the latter to length. Both are projective quantities: they depend upon the choice of the coordinate system, which is supposed to be at rest, *i.e.*, on the definition of rest. In spite of the relativity of height and length and the possibility of assigning to the same building various heights, that height which can be identified with the distance from top to bottom and which corresponds to such a choice of coordinates with respect to which the building will be vertical and will have a length zero—that height, I say, will be justly considered if not the "true" one at least as the most "natural."

The same can be said about definition of distance in time as well as of the distance in space. If you have two different events, then usually you can do either one of the two following things. Either you can choose such a coordinate system that the two events will seem to take place at the same point of space (the corresponding points on the XOY diagram will lie on the same vertical) and the whole space-time distance will then reduce to the distance in time. This can be defined as the "true," most convenient and the most natural definition of the interval of time in the same sense as the height of the building in Minneapolis is the most convenient or natural height.

Or you can select a coordinate system with respect to which the events will appear simultaneous but taking place in different points of space: the distance between the latter can be defined as the most natural length of the line connecting the points of the two events (the ends of a rod, for example).

Lack of time does not permit my giving any further development of these considerations. I would like briefly to point out the chief importance of the relativity theory to physics. This importance does not consist only in this "relativation" of what we thought to be absolute. Much more important is the other side of the theory, which is the establishment of new absolute things or invariable quantities and invariable relations between variable quantities because physical laws must be invariable or "invariant" laws, true irrespective of the definition of rest, *i.e.*, of the choice of the coordinate system with respect to which we are considering the various physical phenomena.

As a compass is to a sailor, so relativity is to physics. It does not enable one by itself to make new discoveries, just as a compass can not be sufficient for the discovery of land. If, however, you have some idea about the direction in which the new land may lie, using the compass you may unerringly reach this land. So with the relativity theory: if a physicist has good intuition, if he knows where he wants to get, then the theory of relativity points the way. He will not err if he follows the path shown by the relativity theory. It is a most important method which has demonstrated its power in Einstein's work on the theory of gravitation (which is connected with the general theory of relativity) and lately in the development of the new quantum theory.

Beyond the "restricted" theory which refers to uniform motion, I can say only a few words. The possibility of generalizing the relativity theory for any type of motion and making relative not only velocities but also accelerations and so on is, as I mentioned at the beginning, due to the fact that forces of inertia connected with non-uniform motion can not be distinguished from forces of gravity. Suppose that a person is restricted to live all his life in an elevator which is moving up and down. How will he register his observations and interpret them? When the elevator starts up you feel heavier and while its ascending motion is being retarded you feel an unusual lightness—as is also the case when the elevator is beginning to descend. Its stopping is again accompanied by a sensation of increased weight. This change of weight is usually described as apparent, due to the addition or subtraction from the "true" weight the force of inertia which is proportional to the acceleration or retardation. Now a prisoner convicted for life to remain in the elevator and not seeing anything outside the elevator will not admit the idea that the elevator is moving up and down and will identify the apparent weight with the true one and assume that the force of gravity of the earth is being changed, that it acts sometimes with a larger, sometimes with a smaller force.

This fusion of forces of gravity with those of inertia into one single whole is the fundamental idea of Einstein's theory of gravitation and the relativity of all motion as expressed by the general relativity theory. If we assume that motion is relative, then we can consider that the elevator remains at rest and that it is the earth which is moving up and down. This is perfectly natural, though somewhat

unusual. We are thinking always that it is the weaker and smaller object that must move, the bigger remaining at rest. It is neither fair not correct from the point of view of the relativity of motion. Let us thus consider that the earth is swinging up and down, the elevator remaining at rest: the result is a change in the pull of gravity due to the earth's motion. The same thing can be said about a "horizontal" motion, such as that of a car. If a car moves very roughly, when starting or stopping you are thrown back and forth; you can say, however, just as well that the car has remained at rest and it is the earth that swayed backward and forward, the gravity force of the moving earth being then directed not downwards, but along an inclined line.

Einstein's theory of gravity amounted to formulating the law of gravity in such a way that it would include the forces of inertia and that it would be valid whatever the system of reference chosen (and supposed to be at rest).

The gravitational theory of Einstein is not actually an *explanation* of gravity, it is only a *description* of gravity, but a more correct description than the theory of Newton.

This theory of Einstein has aroused a great deal of misunderstanding. I think people are especially struck by things they are unable to understand, and they think these "ununderstandable" things are the most important. Einstein's theory of gravity is, I think, associated in everybody's mind with the idea of a "curved" space.

Now what does Einstein mean when he talks about curved space? We must remember that he thinks in mathematical terms, and uses expressions which are misleading to the layman who does not understand the conventional meaning of these words.

Suppose you are on a ship and you drop a stone. As viewed by you or any other person on board it falls vertically in a straight line. As viewed by some person on the shore, the stone will move in a curved line, namely, a parabola with vertical axis. Now this does not mean that the space is curved. It means only that the notion of straightness or curvature is relative in its geometrical aspect. When Einstein talks of space he means actually not space alone but space time, and the curvature attributed to this space-time extension is simply the expression of the fact that there is a lack of uniformity of motion which is due to gravity and which can not be eliminated by a choice of a coordinate system with rectilinear axis. I can not give you the details of that theory, but only an idea of what is actually meant by curvature—it is a kinematical, not statistical or purely geometrical concept.

I can not close without a few words about the retarded propagation of physical forces, which is the corner-stone of relativity, because I have based all my conclusions on this conception, which I not only did not prove but did not explain.

It seems a difficult thing to imagine that forces should be propagated to one body from another through empty space, even if instantly: still more difficult that they are propagated with finite speed, and many people think it is impossible to imagine this and that one must therefore otherwise interpret the facts.

The propagation of light with finite velocity was explained 300 years ago by Huyghens in assuming that space was filled with an elastic medium called the luminiferous ether—a very beautiful name and a very helpful idea for the development of physics. It is queer, but it is a fact that the main merit of the ether theory has been in helping to achieve a unification of physical phenomena. In the nineteenth century Faraday, while studying experimentally electromagnetic phenomena, was biased by the idea that electric and magnetic forces can not be propagated through empty space but only through a material medium, and since it was unreasonable to fill space with another medium, when it was already supposed to be filled with ether it turned out that the ether must transmit not only light vibrations but also electric and magnetic forces. This meant obviously, on the one hand, that light was itself an electromagnetic phenomena and, on the other, that electric and magnetic forces must be propagated with a finite velocity equal to that of light. This result remained in the later development of physics, although the idea or rather the picture of the ether underlying it was destroyed. The theory of the ether had to be abandoned because it led to lots of difficulties. There was however a time—in the second half of the nineteenth century—when physicists thought ether the only thing that really existed, and that matter and all other things were simply manifestations of the motion of the ether. Lord Kelvin, for instance, set forth a theory according to which atoms were just little vortices in the ether. The noted German physicist Drude published in the year 1890 a book on electromagnetic theory which was entitled "The Physics of the Ether."

I should like to write down a translation of a part of an old ode.

> O, thou infinite in space
> And eternal in time
> Whom nobody could comprehend,
> Who fills everything, builds up everything, constitutes everything,
> Whom we call—God.

This ode was written by a Russian poet, Desjavin, 120 years ago and was dedicated to God.

You see, however, that this definition of God fully applies to the ether, and the ether actually was the

god of physicists of the nineteenth century. This analogy between God and ether as a logical concept is very deep indeed. The development of the ether theory followed precisely the same lines as the development of the idea of divinity. In primitive physics ordinary crude substances forming "ponderable bodies" were distinguished from certain divine bodies, imponderable substances like the caloric, electric and magnetic fluids and finally the ether, which were responsible for all the other properties outside gravity, just as in primitive religion the ordinary mortal beings were opposed to divine or immortal beings. Then in physics we had a gradual fusion of various divine imponderable substances to one divine substance, which was the ether, just as in religion we had a fusion of small deities into one big deity, whose properties are defined in the above ode. In physics the process did not stop here but continued (as by the way it is being continued in religion). It did not stop with the electron theory of Lorentz, where the ether was actually stripped of all its physical properties and reduced to the rôle of Newton's "absolute space remaining at rest." This idea of the ether corresponds to the idea of the perfectly neutral God in modern "deistic" religions.

Finally Einstein threw the ether overboard, and through this "atheistic" act opened the way to the discovery of his relativity theory. In his revolutionary step Einstein was helped very much by Michelson's experiment. In trying to measure the velocity with which light was propagated with respect to the ether, which was supposed to fill all space and which in Lorentz's theory was supposed to be at rest, Michelson found that this velocity remains the same in all directions, irrespective of the alleged motion of the earth through the ether, and this result was the starting-point of Einstein's researches that led to getting physics freed from the ether.

We must not be overthankful to the ether, and keep it in spite of the fact that it is no longer useful. It is rather a nuisance, for it interfered with the development of the true theory. Those who were used to think of physical phenomena in terms of the ether theory, *i.e.*, of the theory that physical actions were propagated through ether, were confronted with extremely difficult problems which could not be solved.

From the point of view of the ether theory, astronomical phenomena pointed to the fact that the earth was moving with respect to the ether while terrestrial experiments pointed to the opposite fact that the ether was dragged along by the earth and physicists were at a loss how to reconcile this contradiction. This problem was, however, a purely fictitious one, like many problems discussed by medieval scholars; for instance, those referring to the properties and behavior of the devil. Some said the devil had a tail, others that he did not. Then there was the issue: if he had a tail he must show it, whereas according to the protagonists of the anti-tail theory it has never been seen. But the representatives of the other point of view retorted that the devil concealed his tail so well that it could not be seen. Exactly in the same way argued the protagonists of the ether.

If Michelson failed to discover motion of the earth through the ether, *i.e.*, the drift of the ether with respect to the earth, then said these people, this meant that the ether produced such a longitudinal contraction in the earth and all the terrestrial bodies that its drift could not be observed.

Einstein was the first to recognize that all these difficulties were fictitious, because the ether, like the devil, was not a real object but a product of human imagination which was helpful for some time in the development of physics but detrimental for further progress of science, and he accordingly threw it overboard.

PHYSIOLOGICAL TIME

By Dr. ALEXIS CARREL

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PHYSICAL time, which is measured by a clock, obviously differs from the time which we live. Time is as much a constituent of ourselves as space. Body and consciousness are a history. Existence is identical with duration. This inherent time can not be reduced to psychological time, which consists of the succession of our states of consciousness as consecutive instants. According to the Bergsonian view, these states of consciousness are only instantaneous pictures which stand out against a continuously streaming background. But our duration is certainly much more than the flux of our inner life. It comprehends the whole organism. Mind and body are two aspects of a single thing. We are composed of structural and functional, as well as of psychological changes. The time which we live includes both physiological and psychological times. It is measured in hours, days and years, and assumed to flow evenly, inexorably and at the rate of solar time. Such a supposition is convenient, but its truth should be questioned. Even at a superficial glance, physiological time does not seem to pass at a constant rate through

the frame of physical time. It is a matter of common knowledge that real age differs from chronological age. The value of a year is not identical for short-lived and long-lived animals. Moreover, within a single individual such value seems to vary. Time is said to flow more quickly in old age than in youth. Our duration, then, appears to be independent of physical time. It differs from that measured by a clock, because its substratum is physiological and not physical. If the motion of the sidereal bodies and of the clocks of the earth were simultaneously retarded or accelerated, physiological time would not vary. Each human being constitutes a relatively independent world in a state of continuous transformation. It is the rate of this transformation which can be assumed to characterize our specific duration.

The living organism undergoes two classes of changes: rhythmical and reversible, or progressive and irreversible. These changes are as indispensable a part of the body as the tissues and organs described by the anatomists. Anatomy, to use a definition of Woodger, studies the organism in timeless space. Such a study is imposed by methodological necessity. Its object is not the concrete body, but only an artefact. An organism deprived of duration is just as unthinkable as if deprived of spatial extension. Dead organs and histological sections are nothing but useful abstractions. The body really consists of a flux of structural and functional processes, that is, of an uninterrupted modification of tissues, humors and consciousness. Such is physiological duration. The process of aging starts simultaneously with embryonic life. It is expressed by irreversible changes progressing during the entire span of our existence. The decrease in the rate of growth during infancy and youth, the occurrence of puberty and menopause, the lowering of basal metabolism and the modifications of the skin and hair, etc., appear as the stamp of time on the organism. Most of these phenomena either occupy a relatively short period of our duration or are not susceptible of sufficiently precise measurement. Fortunately, other physiological and chemical processes taking place in tissues or in blood plasma have been found to be measurable during a considerable part of the life span. When small fragments of tissue are removed from an animal and placed in a medium practically deprived of nutrient substances, they manifest some activity and for a few days increase in size. The length of the period of growth and the velocity of the process can easily be ascertained. They express the residual growth energy of the tissues. In an embryo, this residual energy is greater than in a new-born animal. It continues to decrease during youth. But the aging of the organism can not be traced during the whole life by this method because the differences in the growth energy of the tissues of adult and old animals are too small to be accurately detected. Moreover, each type of tissue appears to record time in its own way. A more definite effect of time on living structures is observed when one studies the variations of the rate of healing of a wound in function of the age of the patient. As is well known, the progress of the cicatrization of a wound kept in a sterile condition can be calculated by du Noüy's equation. This equation contains a constant which depends on the size of the wound and on age. After the size of a wound and the constant of cicatrization have been experimentally determined, the age of the patient is easily found. A table established by du Noüy shows the corresponding age for a given size of the wound and a given index of cicatrization. The human beings used as standards belonged to the same race, were in excellent health and lived under identical conditions. Thus, it became possible to ascertain whether an individual is older or younger than his age. This method has given us, for the first time, a means of measuring the passing of physiological time. Unfortunately, it is not practical because it requires the presence of a wound. Moreover, during middle and old age, the differences in the rate of cicatrization become too small to be accurately recorded.

These changes in the growth energy of tissues in function of age are obviously related to simultaneous changes of the humors. The tissues and organs of the body and the interstitial fluids and blood plasma in which they are immersed constitute a relatively closed world. No part of it can undergo any modification without affecting the other parts. While the growth energy and the regenerating capacity of tissues decrease, the functional state and the chemical composition of blood plasma show parallel variations. These variations are irreversible, progress during the entire life and are measurable. Blood serum has been found to possess the property of restraining, under certain conditions, the growth of pure cultures of fibroblasts. The ratio of the area of a colony living in serum to that of a similar colony living in saline solution is called the growth index of the serum. The smaller the index, the greater the inhibiting effect of serum. The serum of a dog a few days old has no inhibiting effect. Its growth index is equal to unity. Soon, it begins to restrain cell multiplication. The growth index decreases very rapidly during the first months of life, more slowly during youth and generally reaches a very small value during maturity. In old age, the variations from year to year are hardly measurable. Although such procedure is only roughly approximate, it has brought to light an important phenomenon: the existence of an irreversible change

in blood plasma which develops from the beginning to the end of life. It has also rendered possible the expression of duration in units of physiological time, and the measurement of the rate of aging of a given animal during practically its whole existence. Should an attempt be made to rejuvenate such an animal, the result of the treatment could be ascertained by the value of the growth index.

The inhibiting effect of serum on cell multiplication is due to the presence of proteins and of lipoids. The serum proteins of a new-born animal do not restrain the growth of colonies of fibroblasts. But their concentration increases as age advances and their nature becomes modified. They rapidly acquire their growth-restraining power. But it is chiefly to lipoids that the inhibiting property of serum must be attributed. These substances increase in quantity and change in quality during life. In old age, they are responsible for the toxic effect on tissue cells which serum manifests *in vitro*. These alterations in the chemical composition of blood plasma can be considered as causing not only the decrease in the value of the growth index, but probably also that of the index of cicatrization in du Noüy's formula.

It is a striking fact that both the index of cicatrization and the growth index of blood serum undergo at the beginning of life a rapid decrease which later becomes slower. The curves representing these indexes slope downward very sharply during youth. At the end of adult life, they are almost horizontal. Therefore, old age may extend over a very long period, when premature senility of some essential organ does not occur. Evidently, the physiological processes responsible for the phenomenon of aging do not advance at an even rate during the whole life. They are far more rapid in infancy than in senescence.

Such processes are the substratum of duration. Their characteristics are those of a stream of organic states which ceaselessly blend with one another in the same manner as the states of consciousness constitute our psychological duration. Physiological time is part of the body, while physical time is foreign to it. The present of a living organism does not pass into nothingness. It never ceases to be, because it remains in the memory and is entered in the tissues. Bergson has clearly shown how the past persists in the present. The body is obviously made up of the past. While the present glides into the past, it seems to assume a spatial form. During development, an animal extends simultaneously in time and in space. Temporal extension is absolutely indispensable to spatial extension. Growth is unthinkable except along one temporal and three spatial axes. In this manner, time is given a spatial representation and considered as a fourth dimension. But such a convenient assumption is probably not accurate. In fact, each spatial dimension also contains temporal elements. At every point of the living things created in space by time, space and time are indissolubly united. Biologists should have conceived long before Einstein and Minkowsky that space and time are not separate entities but constituent elements of a four-dimensional continuum. However, while the organism is evidently located in space time, consciousness can not be completely described within these particular four dimensions.

Physical time flows at a uniform rate. When referred to it, physiological time differs in value from individual to individual, and also from one period to another of the life of a single individual. A unit of physical time may contain larger or smaller amounts of physiological time. It is far richer in organic and neurological events during infancy and youth than during adult and old age. Our duration does not flow at an even rate.

The passage of physical time is inexorable and irreversible. No one can think of controlling it. Physiological time also moves irresistibly. But, owing to the nature of its substratum, it possesses the relative imprecision and variability which characterize biological processes. In recording time, the living organism is far less accurate than an astronomical clock. The rate of its duration may fluctuate. If pathogenic factors happen to modify some of the organs and alter the chemical composition and the physical conditions of the humors, aging becomes accelerated. Physiological time has been found to be not quite inexorable. In lower organisms, its rate can be artificially modified. By drying a rotifer, one may temporarily stop the stream of its duration. On the contrary, when Loeb increased the temperature of the environment of *Drosophila melanogaster*, these flies aged more rapidly. As the organism of the warm-blooded animals is comparatively independent of the outside world, an artificial modification of the processes on which aging depends is a difficult undertaking. However, it would certainly be possible to discover what physiological and psychological disciplines should be offered to human beings in order to increase the span of their life. On the contrary, the problem of rejuvenation, if this word is taken with its full significance, appears to be insoluble. The reversion of physiological time would require a method capable of replacing tissues and humors in the structural and functional state of an earlier life period. Such a method has still to be discovered. It goes without saying that no senescent organism has ever been rejuvenated by the procedures of Steinach and Voronoff. So far, the process of aging remains irreversible.

Physiological duration depends entirely on the presence in the universe of organized living matter. It appears as soon as a portion of space containing metabolizing things becomes relatively isolated from the surrounding world. At all levels of organization, in the body of a minute cell as well as in that of an elephant, the cause of duration seems to consist of the modification of their medium produced by living structures, and of the secondary changes undergone by these structures under the influence of the modified medium. Time is recorded by a cell community only when the metabolic products are allowed to remain around the tissue. The simplest artificial system which shows the phenomenon of aging consists of a colony of tissue or blood cells living in a medium limited in quantity. In such a system, the medium is progressively altered by the products of cell activity and, in its turn, reacts on the cells. Then aging and death take place. The rate of aging of a given colony depends on its size and metabolic activity, and on the volume and composition of the medium. The fate of a tissue differs profoundly according to whether it lives in a small drop of plasma in the limited atmosphere of a hollow slide, or in a flask containing a large quantity of plasma and gases. It is the accumulation of metabolites in the medium which determines the duration of the system cells-environment. If these metabolites are removed at short intervals and the composition of the medium is kept constant, the cell colonies remain indefinitely in a same state of activity. They do not record time qualitatively. In fact, they are immortal. In the simple systems which we have so far considered, the existence of the process of aging must be attributed to the capacity of the environment to be permanently altered by tissue metabolism.

The relations of the tissues and organs to their environment are infinitely more complex in the higher animals than in these artificial systems. Although lymph and blood plasma which constitute the *milieu intérieur*, to use an expression of Claude Bernard, are continuously modified by metabolic products, they maintain a nearly constant composition, owing to the work of the lungs, kidneys, liver, intestines, etc. However, in spite of such an elaborate regulatory mechanism, slow changes, as stated above, take place in the composition of plasma and, under the influence of these changes, the tissues themselves become modified. Such phenomena are bound to a certain constitution of the organism. The fact of duration necessarily depends on the nature and mode of association of the metabolizing elements of the body and of the *milieu intérieur*.

We may conclude that physiological time is a succession of irreversible changes of the system cells-medium; that it can be measured by the rate of these changes and expressed in special units; and that the fundamental constituents of duration are structural and physiological processes bound to a certain type of organization, and specific of each species, of each individual and of the age of each individual. As living organisms are immersed in the physical universe, their duration must either be placed in the frame of physical time or be used as a frame for physical time. In fact, physical time is referred to physiological duration. Then, an important phenomenon takes place: physical time loses its constant value. It extends during infancy, and contracts during old age. Let us suppose two trains starting with the same speed and running on parallel tracks. The first train represents physical time and moves at a constant speed. The second train, on which we travel, represents physiological time and moves at a decreasing speed. At the beginning, the first train remains immobile, because we run as fast as it does. Later, as we advance less rapidly, its speed increases. Finally, when in maturity and old age we slow down, the train symbolizing physical time acquires great velocity and flies away. In the same manner, one year is far longer for a child than for his parents. Young and old people, although spatially united, live in separate universes where the value of physical time profoundly differs. It does not appear that educators and psychologists have as yet realized the importance of the unequal temporal value of the successive periods of life. Although these inequalities are clearly shown only by the measurement of physiological duration, it is certain that they are also a datum of consciousness. During youth, one year seems to be very long, and in old age, very short. Both psychological and physiological times flow in the same direction. But their reciprocal relations remain as mysterious as those of consciousness and cerebrum. Physiological time has the advantage over psychological time of being measurable. Hence, a more complete knowledge of its nature can easily be acquired. Such a knowledge is indispensable to a real understanding of the constitution of the body, which is composed not only of organs, bones, lymph and blood, but also of duration.

OBITUARY

MEMORIALS

THE *Journal* of the American Medical Association reports that a medical and surgical building was completed at the Johns Hopkins Hospital, on November 6, giving the institution a capacity of about 1,000 beds. Half of the building, the Osler Clinic, was com-

pleted and occupied in January; the other half is the Halsted Clinic. These clinics are memorials to the late Dr. William S. Halsted, first professor of surgery, and the late Sir William Osler, first professor of medicine, at the Johns Hopkins University School of Medicine. The addition, which provides about 300 beds, will house only ward patients. The building cost $1,740,000, provided by a gift of $500,000 from the General Education Board and an appropriation from an anonymous gift of $3,000,000.

To honor the memory of a late leader in the field of x-ray work in medicine, a bronze plaque in bas-relief of Dr. Preston M. Hickey, for many years director of the department of roentgenology at the University of Michigan Hospital, will be presented to the university by the American Roentgen Ray Society. The plaque is the work of Mr. Heinz Peter and the presentation will be made by Dr. Leopold Jaches, of New York City, president of the society.

AN oil portrait, painted by William Wirtz, of the late Dean Edward Vernon Howell, of the School of Pharmacy of the University of North Carolina, has been given to the school by Mr. J. Edward Murray, vice-president of the Emerson Drug Company of Baltimore.

A PORTRAIT of the late Edward Mallinckrodt was recently unveiled at the Mallinckrodt Institute of Radiology at St. Louis. Mr. Charles Nagel and Dr. Evarts Graham were the principal speakers.

A MARBLE bust of Thomas Alva Edison, presented by the principal associations of electrical engineers in the United States, has been placed in the Hall of Electrical Engineering in the German Museum (Deutsches Museum) in Munich, next to a bust of Werner von Siemens. Edison was a member of the committee of the museum. Edison exhibits at the museum include pictures and blue prints, original models and exact reproductions covering many of Edison's inventions in the sphere of electricity, as well as several exhibits in connection with some of the other fields of physical science in which he worked.

ACCORDING to the *Journal* of the American Medical Association the British Medical Association has opened a fund to establish a memorial to its founder, Sir Charles Hastings, in celebration of its centenary, which occurs in 1932. A stained glass window in his honor will be placed in the cathedral at Worcester, the city with which Hastings was most closely identified; a tablet will be placed on the house in Worcester where he practiced, and his grave in the Astwood Cemetery in that city will be restored and cared for. Any balance remaining after these objects have been attained will be turned over to the Sir Charles Hastings Fund, the income of which is distributed for the benefit of members of the medical profession and their dependents according to the discretion of its trustees. The opening ceremony of the centenary meeting of the association will be a pilgrimage to Worcester, July 24, 1932, when the memorial window and plaque will be unveiled.

ACCORDING to *Nature* the Polish Physical Society, the Polish Chemical Society, and the Society of Polish Electrical Engineers, with the support and assistance of the Polish Academy of Sciences, Cracow, the Polish Academy of Technology, the scientific societies of Warsaw and Lwow, and various other Polish scientific institutions, arranged for a celebration of the Faraday centenary, on November 6, at Warsaw, in the large hall of the Technical High School. The president of the Polish Republic, Professor Moscicki, and three members of the government were present; the British Embassy was also represented. After a short introductory speech, made by Professor St. Pieńkowski, Dr. Ladislas Natanson, professor of natural philosophy in the Jagellonian University, Cracow, delivered a lecture on the "Life and Discoveries of Michael Faraday." Addresses were also delivered by Professor W. Swietoslawski, of the Warsaw Technical High School, who discussed and explained Faraday's chemical and electrochemical researches, and Mr. T. Czaplicki, who chose for his subject, "Faraday and the Modern Science of Applied Electricity." The proceedings concluded with an exhibition of pictures connected with Faraday's life and work.

RECENT DEATHS

DR. CLARENCE L. E. MOORE, professor of mathematics at the Massachusetts Institute of Technology, died on December 5, at the age of fifty-five years.

PROFESSOR GEORGE HERBERT LAMSON, JR., dean of the division of Arts and Sciences in Connecticut Agricultural College, at Storrs, died suddenly on December 4.

PROFESSOR CARVETH READ, professor emeritus of philosophy and comparative psychology at the University of London, died on December 8 at the age of eighty-three years.

SCIENTIFIC EVENTS

THE WELLCOME RESEARCH INSTITUTION

LORD MOYNIHAN, president of the British Royal College of Surgeons, on November 25 laid the corner-stone of the new buildings for the Wellcome Research Institution which are to occupy the frontage upon Euston Road immediately north of University College.

According to the London *Times* the new buildings, which are already more than half-way to completion, cover the greater part of a block bounded on the east by Gordon Street and on the south by Gower Place, and adjoin the headquarters of the National Union of Railwaymen. Part of the site available was occupied until the present year by the Wellcome Museum of Medical Science and the Wellcome Bureau of Scientific Research, which were established before the war and enlarged and reopened in 1926. The building then existing has been pulled down, and the bodies concerned transferred to other quarters until the new research institution building is completed this spring, when they will be extended over the old site.

It is intended to maintain the Wellcome Museum of Medical Science, with its special exhibits covering tropical medicine and hygiene, upon the ground floor of the new building, with administrative offices, storerooms and lecture-rooms on the basement floors. University classes have made constant use of the old museum, together with many general practitioners and consultants, and the extension has been made principally to enable the teaching facilities of the museum and the Wellcome Bureau of Scientific Research, which it serves, to be extended. The floors above the third story will be utilized principally for laboratories, and it is expected that the accommodation offered hitherto by twelve laboratories to students of medical zoology, parasitology, bacteriology and chemotherapy will be roughly doubled. Physiological and entomological laboratories will be established in the new building, though the Entomological Field Laboratory at Claremont, Esher and the Physiological Research Laboratories at Beckenham will continue undisturbed.

The three floors of the new building immediately above the ground floor and below the new laboratories will be given over to the Wellcome Historical Medical Museum, which will be entirely transferred from its present premises in Wigmore Street next year. While room has been found in Wigmore Street to exhibit such memorial collections as those of Jenner and Lister, and galleries have been devoted to primitive medicine and surgery, and to the folk-lore and anthropological collections associated with them, there has hitherto been insufficient space to show either the links between individual modern pioneers or more than a tenth of the primitive collections.

At the ceremony a bronze casket containing the historical records of the Wellcome Research Laboratories and Museums was inserted in the corner-stone by Dr. Wellcome and Mr. George E. Pearson, and the stone was laid by Lord Moynihan with a silver trowel presented by the architect, Mr. Septimus Warwick.

In his address, Lord Moynihan paid tribute to the forty years' work of Dr. Wellcome in promoting medical research.

NEW BIRD SANCTUARIES

THE Migratory Bird Conservation Commission, of which Secretary Hyde, of the Department of Agriculture, is chairman, authorized on December 3 the acquisition of lands by the Bureau of Biological Survey for ten migratory game-bird refuges in New York, Maryland, North Carolina, South Carolina, Florida, Nebraska, North Dakota, Wyoming and Nevada. The area amounts to 43,227 acres. The cost to the government will average $5.74 an acre.

Including the lands approved by the commission, 154,744 acres have been authorized for acquisition by lease and by purchase since the migratory-bird refuge program was initiated in 1930. In addition 65,970 acres have been set aside by executive order and presidential proclamation, making a total of 220,713 acres established or in the process of being established as inviolate federal sanctuaries for migratory birds. Refuges have been established in California, Nevada, Montana, Wyoming, North Dakota, Nebraska, Oklahoma, Florida, South Carolina, North Carolina, Maryland and New York. The average cost per acre of all lands approved for purchase under the act is $4.30.

In New York the commission authorized the leasing of lands for the Hempstead Migratory Bird Refuge, an area of 2,274 acres of land and water adjacent to Howlett, Long Island. Because it is on the Atlantic coast flight route of migratory birds and near to the metropolitan area of New York this is considered an important link in the eastern chain of refuges.

An important acquisition is the Blackwater Migratory Bird Refuge on the eastern shore of Maryland. This unit, situated about 10 miles from Cambridge, Maryland, contains approximately 10,000 acres, including marshes where black ducks and blue-winged teal breed in greater numbers than on any other area on the eastern seaboard south of Labrador. Mallards and pintails also concentrate on the marshes during the migration season.

In the Swanquarter Migratory Bird Refuge in Hyde County, North Carolina, acquisition of 3,600 acres contiguous to tracts previously approved was authorized. With the water areas this tract borders, the refuge will now make an administrative unit of about 25,000 acres.

Acquisition in South Carolina of approximately 414 acres of land will complete consolidation of government-owned land in the Cape Romain Refuge. The total area in this unit is now about 33,000 acres.

The acquisition of 5,285 acres for the St. Marks Refuge, Florida, will consolidate the government

holdings there. With nearly 14,000 acres approved for acquisition a year ago this brings the total area in the process of acquisition to 19,167 acres.

Crescent Lake Migratory Bird Refuge, Nebraska, will be extended by the acquisition of 1,688 acres, including several extensive water areas and numerous ponds and potholes. The acquisition will also tend to round out the boundaries of this sanctuary, which now includes about 40,000 acres.

By approving the acquisition of numerous small tracts bordering on Long Lake, in Kidder and Burleigh Counties, North Dakota, the commission took steps looking to the establishment of the first federal migratory-bird refuge in that state. The total area approved Dec. 3 for acquisition there is 4,269 acres.

The acquisition of 3,465 acres in Wyoming is the first to be approved for that state. Two refuges about 12 miles apart, one at Bamforth Lake and the other at Hutton Lake, both near Laramie, will be acquired.

The lands being acquired in Nevada will be additions to the 17,902 acres of the Fallon Migratory Bird Refuge set aside from the public domain by executive order in February, 1931, as a sanctuary for migratory birds. The total area will now be 31,288 acres.

THE SEVENTH AMERICAN SCIENTIFIC CONGRESS

THE seventh American Scientific Congress will be held in Mexico City from February 5 to 19, 1932, under the presidency of Dr. Alfonso Prunada, rector of the National University.

In addition to the opening and closing ceremonies and such other general sessions as may be arranged, the congress will meet in the following twelve sections: Physical and Mathematical Sciences, General and Applied Geology, Engineering, Industrial Chemistry, Biology, Scientific Agriculture, Medicine, Hygiene and Public Health, Anthropological and Historical Sciences, Juridical Sciences, Social and Economic Sciences and Education.

The official languages of the congress will be: Spanish, French, English and Portuguese. The papers presented to the congress may touch on all matters of scientific interest, as set forth under the headings of the different sections, and may treat the subjects from the point of view of pure science or from that of applied science. Abstracts should be sent to the general secretary, Dr. Pedro de Alba, at an early date, in order that they may be put in type for distribution at the meeting.

The following statement in regard to the history of the congress has been made by the organizing committee:

> In 1896, and in order to commemorate the twenty-fifth anniversary of its foundation, the Scientific Association of the Argentine Republic invited the countries of Latin-America to a Latin-American Scientific Congress, which was held in Buenos Aires from the 10th to the 21st of April, 1898. Following upon this assembly, the second and third of these congresses were held in Montevideo and in Rio de Janeiro, respectively, in 1901 and 1905.
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> The fourth Latin-American Scientific Congress was held in Santiago de Chile in December, 1908, and owing to a resolution adopted by the Chilean Government, the congress was named First Pan-American Scientific Congress. The second and third congresses under this new denomination were held, respectively, in Washington (1919) and in Lima (December, 1924, to January, 1925).
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> The congress assembled in Lima determined that the next congress be known as the Seventh American Scientific Congress and appointed San Jose de Costa Rica as the city where it was to be held; owing, however, to various circumstances, the congress could not be held in that city, and accordingly the Board of Directors of the Pan-American Union (formed by the diplomatic representatives of the various nations in Washington) consulted the Mexican Government as to the advisability of holding the congress in Mexico City. The Mexican Government, after consulting the case with the Ministry of Public Education, expressed its approval of the proposal, and thus it was determined that the assembly be held in the City of Mexico in February, 1932.

The organizing committee extends a cordial invitation to all scientific men of America to attend the congress and to take part in its labors. "The sessions will promote the knowledge of the progress made in the various countries of the continent, in order to study and discuss some of the outstanding problems of those nations and will help to set up closer bonds of lasting friendship between the various countries. Mexico awaits enthusiastically the visit of those who will be its guests for a few days, during which both the authorities and the organizing committee will spare no effort to make their stay in the country as agreeable as possible in every way."

All correspondence with reference to the congress should be addressed to: Comision Organizadora Del Septimo Congreso Cientifico Americano, Apartado Postal 517, Mexico, D. F.

AWARD OF THE EDISON MEDAL TO DR. EDWIN W. RICE, JR.

THE Edison Medal for 1931 has been awarded by the American Institute of Electrical Engineers to Dr. Edwin Wilbur Rice, Jr., "for his contributions to the development of electrical systems and apparatus and his encouragement of scientific research in industry."

The Edison Medal was founded by associates and friends of Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee consisting of twenty-four members of the American Institute of Electrical Engineers.

The following eminent engineers and scientists have been recipients of the medal: Elihu Thomson, Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell, Nikola Tesla, John J. Carty, Benjamin G. Lamme, W. L. R. Emmet, Michael I. Pupin, Cummings C. Chesney, Robert A. Millikan, John W. Lieb, John White Howell, Harris J. Ryan, William D. Coolidge, Frank B. Jewett, Charles F. Scott and Frank Conrad.

Dr. Rice is one of the pioneers of electrical development in the United States and has played a conspicuous part, in association with the late Charles A. Coffin, in the building of the General Electric Company.

As a school-boy in Philadelphia he came in contact in 1876 with Professor Elihu Thomson, then a young teacher in the Boys' Central High School. His natural fondness for mechanics and later for electricity was quickly developed by this association, and when in 1880 Dr. Thomson gave up teaching to go into electrical manufacturing as investigator and inventor, Rice became his assistant.

He went with Dr. Thomson to New Britain, Connecticut, in the old American Electric Company, and in 1883 went with him to Lynn, Massachusetts, when the Thomson-Houston Electric Company was organized. At the age of twenty-two years he was made plant superintendent and had full responsibility until the consolidation of the Thomson-Houston Electric Company and the Edison General Electric Company in 1892, under the name of General Electric Company.

In the new company Mr. Rice was first made technical director, then vice-president in charge of manufacturing and engineering. He eventually became senior vice-president, and in 1913 he succeeded Mr. Coffin as president of the company. In 1922, after nine years' service in that office, Dr. Rice was succeeded by Mr. Gerard Swope and Dr. Rice was made honorary chairman of the board, which position he still holds.

Dr. Rice has contributed much through organization methods, improved factory routine, technical development, and engineering and scientific inventions. He invented the present fundamental form of high-voltage oil switch and the cellular system of separating fuses and circuits; as well as the application of synchronous converters to the building of unified alternating and direct-current distribution systems. He was responsible for the establishment of the General Electric research laboratory.

SCIENTIFIC NOTES AND NEWS

THE first session of the council of the American Association for the Advancement of Science at New Orleans will be held in the Gold Room, Roosevelt Hotel, at 2:00 o'clock on Monday afternoon, December 28. It is hoped that a large attendance of council members will be present, as important matters are to be considered. Later sessions of the council will occur at 9:00 on the mornings of Tuesday, Wednesday, Thursday and Friday, December 29, 30, 31 and January 1. These sessions are to be adjourned in time for council members to attend the scientific sessions that begin at 10:00 o'clock.

DR. FREDERICK V. COVILLE, principal botanist in charge of the division of botany of the Bureau of Plant Industry; acting director of the National Arboretum; curator of the United States National Herbarium at the Smithsonian Institution, and chairman of the research committee of the National Geographic Society, recently was awarded the George Robert White Gold Medal of Honor by the Massachusetts Horticultural Society for distinction in botanical fields.

THE Henry S. Wellcome Medal and Prize of $500 have been awarded to Colonel George A. Skinner, chief surgeon, seventh corps area, U. S. Army, Omaha, for a paper on "The Influence of Epidemic Disease on Military Operations in the Western Hemisphere." The Wellcome award was established in 1916 to encourage study and research on problems connected with the health of armies and the efficiency of the medical services.

PROFESSOR KALMAN J. DEJUHASZ, of the Pennsylvania State College, was presented with the Rudolph Diesel Award at the recent annual meeting of the American Society of Mechanical Engineers. The award was made for a paper on Diesel engine operation entitled "Dispersion of Sprays in Solid Injection Oil Engines."

THE Institution of Civil Engineers, London, has awarded the Indian Premium for the session 1930–31 to Mr. G. C. Minnitt, Bombay, for a paper read and discussed at an ordinary meeting of the institution. They have also made the following awards in respect of "Selected Engineering Papers" published without discussion: A Telford gold medal to Mr. Herbert Addison, Giza, Egypt; Telford premiums to Messrs. H. A. Sieveking, London; William Blackadder, Aberdeen; R. F. Legget, Montreal, and jointly to Messrs. R. G. C. Batson and H. R. Mills, Teddington.

THE Buckston Browne Prize and Medals of the Harveian Society of London have been awarded to Mr. Cecil P. G. Wakeley and Mr. Laurence O'Shaugh-

nessy, whose essays on "The Treatment of Shock by Intravenous Therapy" were deemed to be of equal merit.

Nature reports that at a general meeting of the French Society of Electrical Engineering on November 7, it was decided to confer the title of honorary member on Mr. Percy F. Rowell, secretary of the Institution of Electrical Engineers, in recognition of his work in establishing close collaboration between the French society and the Institution of Electrical Engineers, particularly during the Anglo-French Congress held in Paris in 1913, the meeting of the institution held in France in 1929, and the Faraday celebrations held in London in 1931.

THE degree of LL.D. has been conferred by the University of Manchester on Professor F. E. Weiss, formerly Harrison professor of botany, on his retirement from active service and in recognition of his long and distinguished membership of the teaching staff.

DR. SVEN HEDIN, of Stockholm, the explorer, has had an honorary doctorate conferred on him by the Berlin Institute of Commerce.

DR. HANS MOLISCH, professor of the anatomy and physiology of plants at the University of Vienna, celebrated his seventy-fifth birthday on December 6.

PROFESSOR DOUGLAS JOHNSON, of Columbia University, has been elected to honorary life membership in the National Geographic Society in recognition of his "contributions for the increase and diffusion of geographic knowledge."

DR. A. RICHARD BLISS, JR., chief of the division of pharmacology, College of Medicine, University of Tennessee, was elected president of the Tennessee Academy of Science at the annual meeting at Nashville on November 28.

AT the thirty-fourth annual meeting on December 10 of the Massachusetts Forestry Association, Mr. Harvey N. Shepard, of Boston, was elected president.

AT the anniversary meeting of the Mineralogical Society, London, Sir John S. Flett was elected president. The vice-presidents are Dr. G. F. Herbert Smith and Professor C. Gilbert Cullis.

DR. WILLIAM S. LADD, formerly on the faculty of the College of Physicians and Surgeons, Columbia University, has been appointed assistant professor of medicine and associate dean of Cornell University Medical College.

IT is announced in *Nature* that Dr. J. Ward, senior lecturer in mechanical engineering at the Northampton Polytechnic Institute, London, has been appointed head of the department of civil and mechanical engineering at the Technical College, Huddersfield, in succession to Mr. J. W. Button, who is about to retire after twenty-four years' service as head of the department.

AT the University of London, Mr. F. W. Twort, F.R.S., of the Brown Animal Sanatory Institution, has been promoted to a professorship of bacteriology, and Dr. H. A. Harris, University College and University College Hospital, to a professorship of clinical anatomy.

DR. JOHN HAROLD ANDREW, professor of metallurgy at the Royal Technical College, Glasgow, has been appointed to the chair of metallurgy at the University of Sheffield.

THE first Arthur lecture of the Smithsonian Institution, endowed by the late James Arthur, to promote study of the sun, will be given on January 25 by Dr. Henry Norris Russell, of Princeton University, on "The Composition of the Sun." In March Dr. Aleš Hrdlička, of the National Museum, will lecture on his recent archeological explorations in Alaska dealing with the coming of man from Asia to North America.

DR. FREDERICK H. SEARES, assistant director, Mount Wilson Observatory, Carnegie Institution of Washington, gave on December 8, before the Carnegie Institution of Washington, an illustrated lecture on "The Stars about Us."

DR. G. E. COGHILL, of the Wistar Institute of Anatomy and Biology, Philadelphia, delivered an address before the Royal Canadian Institute on November 28 on "Reflex Action in Development and Behavior."

THE Frazer Lecture in social anthropology was delivered at the University of Cambridge on November 26 by Sir Arthur Evans on "Some Aspects of the Earlier Religion of Greece in the Light of Cretan Discovery."

THE forty-seventh meeting of the American Astronomical Society will be held in Washington, D. C., from December 28 to 30.

THE one hundred and seventy-fourth regular meeting of the American Physical Society will be held in Le Conte Hall, University of California, on December 18 and 19. Unless it is necessary to continue the scientific sessions, Saturday afternoon will be spent in tours of inspection of the department of physics of the university for those members who wish to see the researches in progress.

THE third International Congress of Eugenics will be held under the auspices of the International Federation of Eugenic Organizations. The scientific papers and the social features of the congress will be centered at the American Museum of Natural History in New York City and at the Eugenics Record Office in Cold Spring Harbor, from Sunday,

August 21 to Wednesday, August 24, 1932. Following the congress many members of the congress, particularly those interested primarily in genetics, will go to Ithaca, N. Y., where the Sixth International Congress of Genetics will be held from August 24 to 31. On Monday, August 22, the Eugenics Exhibit will open in New York, closing on September 22. Members of the Exhibits Committee are: William K. Gregory, Frederick Osborn, George H. Sherwood, Clark Wissler and Harry H. Laughlin, *chairman*. It is the purpose of this exhibit to show the history, content, present researches and trends of eugenics, both as a pure and an applied science. It will seek to emphasize the fact that eugenics is concerned primarily with racial and family-stock quality in the turnover of population from generation to generation.

THE ninth International Congress of the History of Medicine will be held in Bucharest in September, 1932. The principal subjects for discussion will be the evolution of medicine in the Balkan states and the protection of Europe against bubonic plague. Those wishing to contribute papers are requested to forward the title and a summary of the paper to the office of the congress, Str. Stirbey Voda, 86, Bucharest II.

ACCORDING to *Nature* the British Institute of Radiology, incorporated with the Röntgen Society, held its annual conference from December 2 to 4. With the conference there was an exhibition of apparatus, organized by the Associated Manufacturers. The conference was opened by the Right Honorable Lord Rutherford, and Dr. A. E. Barclay delivered the presidential address. Besides several technical papers there were two lectures: the fourteenth Silvanus Thompson Memorial Lecture by Sir James Jeans, on radiation, and the twelfth Mackenzie Davidson Memorial Lecture by Professor Dr. Hans Holfelder, on medical, surgical and radiological treatments of disease. Cinematograph films illustrating experiments on the inflammability of films (Prof. F. Haenisch) and the effects of radium on living cultivated tissues (Dr. R. G. Canti) were exhibited.

PUBLIC lectures will be given beginning with January 9 on Saturday afternoons at 3:30 at the New York Botanical Garden during January and February. The subjects and speakers are as follows: "Outdoor and Indoor Ferns," Dr. Ralph C. Benedict, Brooklyn Botanic Garden. "Planting and Growing Conifers," Mr. Alexander Michie, nursery manager for T. A. Havemeyer. "Roses," Dr. B. O. Dodge, plant pathologist. "Begonias," Mr. T. H. Everett, head gardener at the Manville Estate, Pleasantville. "Flowering Shrubs," Mr. J. H. Beale, Boyce Thompson Institute, Yonkers. "Annuals," Mr. Kenneth R. Boynton, head gardener. "Water Lilies and Their Care," Mr. H. W. Becker, in charge of greenhouses. "Dahlias and Chrysanthemums," Dr. M. A. Howe, assistant director, and Mr. Kenneth R. Boynton, head gardener.

THE London *Times* reports that Christmas scientific lectures and experiments for children have been arranged by various institutions in London as follows: Professor E. N. da Costa Andrade, Quain professor of physics at London University, will give the Royal Society of Arts lectures in the afternoons of January 6 and 13. His subject will be "The Vacuum, or the Importance of Nothing at All." Sir William Bragg will lecture at the Royal Institution on December 29 and 31 and January 2, 5, 7 and 9. His subject will be "The Universe of Light." At the Royal Geographical Society will be given lectures on January 4 and 8. The first lecture will be by the President, Admiral Sir William Goodenough, who will speak on "South and East." The second, "Through Lapland in Winter with Sledge and Reindeer," will be given by Mrs. Murray Chapman. Mr. E. R. Jarrett will deliver the Royal Institute of British Architects' lectures on December 28 and 30 and January 1. Special films will be shown at the Imperial Institute cinema.

ONE of the most valuable private zoological collections in existence, numbering 30,000 skins and many thousand birds and eggs, including the rarest North American specimens, has been given to the Harvard Museum of Comparative Zoology by Mr. John E. Thayer, ornithologist, of Lancaster, Massachusetts, a graduate of Harvard University in the class of 1885. The collection was assembled at great cost and labor. Expeditions were sent by Mr. Thayer to Alaska, northeastern Siberia, the Queen Charlotte Island, Lower California and Northern Mexico. The gift also included ten eggs of the great auk. Harvard now has eleven auk eggs, or about one sixth of all known existing specimens.

THE Carnegie Corporation of New York has made a grant of $30,000 to the British Museums Association for the survey of the museums of the British Empire outside the British Isles.

ACCORDING to the *Journal* of the American Medical Association, the Laboratory of Marine Biology was recently dedicated at Rovigno, Istria. The origin of the institute dates back to a zoological station established at Rovigno by Germany in 1891. A recent agreement entered into by the governments of Italy and Germany provides that the institute shall be regarded as the joint property of the two countries, which will share equally the current expense of its administration and will have an equal number of persons on its staff. Professor Sella has been ap-

pointed codirector for Italy and Professor Stener for Germany. The institute has important collections of fish, mollusks and crustaceans. Researches have been made on ocean depths, ocean currents and water pressure at various ocean depths.

THE London *Times* states that the Governors-General of Algeria and of French West Africa have organized a scientific expedition across the Sahara to Central Africa. M. A. Chevalier, professor of applied botany at the French National Museum of Natural History, who has spent many years in studying agriculture and vegetation in the French colonies, heads the expedition. The expedition will visit the oases of Southern Algeria—which is part of the Sahara—to study the vegetation and see if new plants and trees can be introduced. For this purpose slips and cuttings from the best Biskra date palms, notably the "deglet-nour" (Finger of Light) variety, are being taken by the expedition. At Reggan, in the heart of the Sahara, a permanent experimental botanical garden will be established. From Niamey, on the Niger, the expedition will go towards Air and Lake Chad, across country where for the most part the vegetation will be scientifically studied for the first time, to get museum specimens. Here, too, the expedition will carry out important investigations into the laying and breeding places of the African locust. The expedition will return to France by way of the French Sudan and Senegal, in which region it will study the local methods of growing cotton, sisal, groundnuts and native cereals.

ACCORDING to the London *Times* the second annual report of the Executive Council of the Imperial Agricultural Bureaus states that there are now eight bureaus controlled by the council, on which all the Dominions are represented. The funds are provided jointly by the Dominions, the colonies and the home country. During the year, 1930–31, reviewed the council continued to receive the full support of all contributing countries, in spite of acute financial difficulties in many of those countries. The bureaus act as clearing-houses of information in the field of agricultural science and keep Empire research workers in touch with each other and with the latest scientific advances in other countries. During 1930–31 contacts were established with research workers all over the Empire. Over 2,000 names are now on the mailing list to receive the publications of the various bureaus, each of which is established at a leading research station in this country. Three special conferences were organized by the bureaus, and they dealt with soil science, animal health and fruit production. These conferences were well attended by research workers both in the United Kingdom and in the Empire oversea, and at all of them technical questions were discussed as well as the work of the bureaus. Several officers attached to the bureaus have toured one or more of the Dominions to establish personal contact with research workers. Three of the bureaus —those dealing with animal genetics at Edinburgh, plant genetics at Aberystwyth and animal health at Weybridge—now issue regular journals containing abstracts of new and important research papers and bibliographies of publications, in foreign as well as in Empire countries. The report records a resolution adopted by the Imperial Conference, 1930, declaring that the bureaus provide "both a notable precedent for action on a true Commonwealth basis and a contribution that is already bearing fruit in the better dissemination of scientific knowledge throughout the Empire."

The Museums Journal reports that the South African Parliament has established two new game reserves: one in northwestern South Africa between the Aub and Nossob Rivers will provide sanctuary for gemsbock or oryx, kudu, eland, gnu, lions, leopards and rare birds; the other in the eastern part of the Union, the Addo reserve, is the last refuge of a few South African elephants. The new reserves are administered by the National Park Department.

FOR the purpose of conducting further tests in the field of radio wave propagation, the University of Washington has placed both the personnel and apparatus of its Scientific Research and General Engineering Departments at the disposal of the National Park Service, according to an announcement made by Dr. Ray Lyman Wilbur, Secretary of the Interior. Experiments with radio as a means of communication in national parks have been in progress in Mount Rainier National Park in the State of Washington for some time and have demonstrated a sufficient limited use of radio as a means of communication in primitive areas such as the mountainous parks, especially in forest-fire emergencies and interrupted telephone communication caused by storms, to justify further experiments. Mount Rainier now has the first system of radio communication ever to be established in a national park. Late in the summer call letters for six stationary and four portable stations were assigned to Mount Rainier by the Department of Commerce. The university is now building a radio station to aid in this work. Two of the permanent stations in Mount Rainier Park are at Longmire, and the others at Paradise, Sunrise and the White River and Carbon River entrances to the park. These stations have a ten-tube combination modulated by four tubes for voice and six tubes for code. The portable sets, which will, of course, be carried by rangers on patrol, will prove especially effective in emergencies.

DISCUSSION

A SUBMERGED BEACH OFF BERMUDA

WORK has been continuous this summer on the Third Bermuda Oceanographic Expedition. This is carried on as before, under the directorship of the writer, by the Department of Tropical Research of the New York Zoological Society.

In the course of the researches on the limited deep-sea area under intensive study, some interesting new discoveries have come to light and one in particular. The area covered in the season of 1931 was, as before, roughly a circle eight miles in diameter, with its center 32° 12′ North Latitude and 64° 36′ West Longitude, which point is 160 degrees by the compass, or south-south-east of Nonsuch Island, Bermuda. This brings the center of the circle 6.75 miles from the nearest one hundred fathom line and 9.25 miles from the laboratory on Nonsuch.

In addition to the regular trawling, attention has been given this season to temperatures and water samples, and work on the bottom. Accidental touching of the bottom from time to time by the silk nets has shown that this lies within the small area of pteropod ooze which was discovered many years ago south of and close to Bermuda. These nets were usually torn, and a large otter trawl which I lowered one thousand fathoms to the bottom was ripped half across.

Four-foot iron dredges were used this year with unexpected results. About two hauls were made with each dredge before it was lost, and at each successful haul the dredge was bent almost double. One-half square-inch mesh netting was used on the dredge, which allowed most of the pteropod ooze to slip through. What remained was of great interest, since it consisted almost entirely of water-worn pebbles, shells and bits of coral. Several hauls were made at nine miles distance from shore, and later others at twelve miles yielded the same general material.

The lowest levels of oceanic water at the glacial periods have permitted to geologists estimates of an increased Bermudian land area from almost twenty square miles of the present dry land, to 230 square miles, including all the shallow waters to the outermost reefs. An actual rise and subsidence of the land itself is admitted, a change in altitude, however, not exceeding 150 feet.

The gradient of the sea bottom south and southeast of Nonsuch, out to nine miles, is, to judge by my soundings and those marked on admiralty charts, about one in six.

The depths at which my dredge hauls were made, where absolute evidence of submerged sea beaches was brought up, were 1,450 to 1,550 fathoms, over one and a half miles deep. This was in perfect conformity with the proven roughness of the bottom over almost all the area in the eight-mile circle. The sea-floor at 1,000 to 1,500 fathoms is usually comparatively smooth and flat. But here my nets and dredges have encountered obstacles at every trawl, obstacles similar in hardness, and in the bits of broken rocks which came up, to the water and air-worn reef rocks in shallow water near the shore.

I have submitted my shells to Mr. Arthur Haycock, who has kindly identified them; and Dr. C. M. Yonge, of the Marine Biological Association, while on a recent visit to Nonsuch, was good enough to look over the alcyonarians and corals.

I have had no opportunity to extend the dredgings beyond my eight-mile circle, but, at the most conservative estimate, the addition to a former Bermudian land mass is more than sixty times. In other words, the present dry land of Bermuda is slightly less than the area of Manhattan Island (19.3, as compared with 22 square miles), while the area added by the inclusion seaward of these submerged beaches would increase this to 576 square miles. This is only an estimate, but, based on these preliminary facts, it is probably far under the truth.

A complete report will be forthcoming. Here it will suffice to say that the majority of the waterworn bivalves are *Glycimeris* and *Pectunculus,* nearly fifty of which were taken in Dredge No. 1224, at 1,500 fathoms. With these were *Arca imbricata,* a *Cardium, Cryptodon chrisostoma, Ostrea frons, Chione latilirata,* etc. Also bits of limestone affected by volcanic action. The pteropods remaining in the coarse dredge nets were chiefly *Cavolinia* and *Cuvierina.*

Some of these shells have been found fossil in Bermuda by Mr. Haycock, together with similar waterworn pebbles in old raised beaches thirty feet above high water, and most of them are West Indian species.

The bottom of my trawling area appears to alternate tall, exposed, reef-like, sharp-edged, water-worn limestone, with stretches of water-worn shells, coral fragments, rounded limestone pebbles, covered several inches deep with an almost pure culture of pteropod shells of five or six species, unusually deep for this type of ooze: This at a distance of five to thirteen miles from the outer reefs off Nonsuch. The bottom has so slight a gradient and is of so rough a nature that any gradual rolling or washing down from higher levels is unthinkable.

The discovery of a submerged sea-beach of great

extent, *in situ*, at a depth of 1,500 fathoms, was quite unexpected in this part of the Atlantic.

WILLIAM BEEBE

NEW YORK ZOOLOGICAL PARK

POSITION OF WOOD IN BEAVER DAMS

A TYPICAL beaver dam is a bank of earth reinforced with brush, in vertical sections approaching an equilateral triangle with a rounded apex. The reinforcing branches do not show on the upstream side of the dam; the slope in that direction is covered with a thick layer of solid earth. But on the downstream side the branches continue outward as a bed of brush a foot or so thick, covering the face of the dam from crest to foot, their very important function being to prevent erosion by the water flowing over the dam.

Every writer known to me who goes into details of beaver dam construction, says that these branches are placed with their butts upstream. Thus Morgan[1] writes in his monograph: "In general the large ends of the poles and of the limbs with their branches attached were upstream, which itself would tend to strengthen their hold on the bottom."

Mills[2] says: "The majority of dams are made of slender green poles. . . . With these are used occasionally small limby trees. The large end of the trees is placed upstream and the bushy end downstream."

Equally definite is Dugmore:[3] "As a matter of fact the building of an ordinary dam consists originally of a number of sticks and brush being laid (no stakes are driven) in the water with butts upstream."

Johnson[4] makes some qualifications: "Boughs are generally found with the butt end upstream, but numerous examples occur where they lie across the current, diagonally and in every intermediate position."

And lastly Warren,[5] in the best book yet written on the beaver: "Branches of willow, alder or whatever brush is most available . . . are cut and placed on the bottom with the butt ends upstream, and often forced into the bottom."

Now for twelve years I have been observing the work of a beaver family established on a small stream tributary to the Ottawa River near Arnprior, Ontario. There is nothing out of the ordinary in the situation. The stream rises in a group of springs, and with a moderate current flows a distance of two miles through a shallow thickly-wooded valley. Before the beavers came it had a fairly uniform width throughout its whole length of four to six feet, and a depth varying from six inches in its upper part to three or four feet in its lower reaches. The beavers occupy the last half-mile of the stream, where there is, or rather was a good supply of poplar and other favorite woods, and their dams have expanded this section of the stream into a pond four or five feet deep and about 300 feet wide.

At one time and another these beavers have built nine dams, and have rebuilt or repaired five or six dams that broke. In every case, both in new work and repairs, the great majority of the branches used in construction were laid with butts *downstream*, in direct opposition to the beaver practice unanimously alleged by the writers quoted. As mentioned by Johnson,[4] some of the branches were placed in every possible position, but at least 90 per cent. with butts downstream. To venture on an *a priori* argument, it may be said that this disposition of the branches is what might be expected. In general, beavers float their wood downstream: naturally it is towed butt-end first to prevent twigs and branches from catching, and it is likely to be laid in position without change of direction, that is, butts downstream.

Certainly such is the habitual and uniform procedure of my beavers, both in new construction and repairs. There is no reason to suppose that they differ in any way from other beavers, and there does not appear to be anything in their environment that might cause a reversal of habit.

I have had no opportunity of examining critically beaver dams elsewhere, but perhaps some field naturalist who is familiar with dams in different parts of the country will say if the wood in other dams really is laid with butts upstream.

CHARLES MACNAMARA

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CANADA

[1] Lewis H. Morgan, "The American Beaver and its Works," p. 103, 1868.

[2] Enos A. Mills, "In Beaver World," p. 66, 1913.

[3] A. R. Dugmore, "The Romance of the Beaver," p. 34, n. d. (ca. 1914).

[4] C. E. Johnson, "The Beaver in the Adirondacks," *Roosevelt Wild Life Bulletin*, p. 632, July, 1927.

[5] E. R. Warren, "The Beaver," p. 28, 1927.

VIRGINIA GEOLOGICAL SURVEY FIELD WORK

DURING 1931 the Virginia Geological Survey has conducted an extensive program of field work, under the supervision of the State Commission on Conservation and Development, Mr. William E. Carson, chairman, and Dr. Arthur Bevan, state geologist. The results of each of these projects will probably be published as survey bulletins.

This field work consists of the following projects:

The survey of the geology and mineral resources of the Hot Springs district in the central-western part of the state is being continued by the state geologist. He has been assisted at times by Mr. C. R. L. Oder, of the University of Illinois, Mr. Paul Averitt, of the University of Kentucky, and Mr. R. L. Laurence, of the University of Cincinnati. This area is also being topographically mapped, in cooperation with the

U. S. Geological Survey, in four 7½-minute quadrangles on a scale of 1:24,000 and a contour interval of 20 feet. The relief is about 3,000 feet. The formations range from Lower Ordovician (Upper Canadian) to Upper Devonian, inclusive.

Field work and a report on the Caverns of Virginia have been completed by Mr. William M. McGill, assistant state geologist. This report is of an educational character. A study of the geologic relations of the "natural wonders" in the state and a survey of the resources of certain counties are also being made by Mr. McGill.

Three projects are being surveyed in cooperation with the U. S. Geological Survey. Dr. Charles Butts is completing a study of the stratigraphy and structure of the Appalachian Valley in Virginia. He has been assisted this season by Mr. Benjamin Gildersleeve, of the University of Virginia. A geologic map is being prepared for publication on a scale of 1:250,000. This will be followed by a report on the Paleozoic formations of Virginia west of the Blue Ridge.

A field study of the lead and zinc district along New River in Smyth and Wythe counties has been completed by Dr. Louis W. Currier, assisted by Mr. H. E. Thomas. The mineralized zones occur in the Shady dolomite (Cambrian).

A study of the ground-water resources of northern Virginia has been begun by Mr. R. C. Cady. This will cover the northern tier of counties, thus including Paleozoic rocks of the northern Valley region, Cambrian and pre-Cambrian rocks of the Blue Ridge, pre-Cambrian and Triassic rocks of the Piedmont province, and Cretaceous sediments along the western edge of the Coastal Plain.

A study of the Lower Cambrian red hematite beds of the Blue Ridge northeast of Roanoke is being completed by Professor Roy J. Holden, of Virginia Polytechnic Institute, Blacksburg. These iron deposits were extensively mined until a few years ago, and large reserves still exist.

The geology and mineral resources of Brunswick County, in the southeastern part of the Piedmont province, have been mapped by Professor A. A. Pegau, assisted by Mr. J. S. Johnston, both of the University of Virginia.

A study of the lower part of the Williamsburg peninsula, between James and York rivers, has been made by Professor J. K. Roberts, of the University of Virginia, assisted by Mr. Henry Crenshaw, of Emory and Henry College. The geologic history of the Jamestown-Williamsburg-Yorktown region will be stressed in the report.

The commercial granites and allied rocks in the Piedmont and Blue Ridge provinces have been studied by Colonel Edward Steidtmann, of Virginia Military Institute, assisted by Mr. Chamberlain Ferry, of Washington and Lee University. Granite production in Virginia in 1929 had a value of more than one million dollars.

A survey of the belt of kyanite deposits, in the southwestern part of the Piedmont province, has been made by Dr. Anna I. Jonas.

The geology and mineral resources of Goochland County have been surveyed by Mr. Carl B. Brown, recently at the University of Cincinnati. This county is in the eastern Piedmont province, including parts of the gold belt and of the Richmond Triassic coal basin.

A survey of the slate resources of the Piedmont province has been made by Dr. J. D. Burfoot, of Cornell University. Commercial operations are now confined to two localities: (1) In the outlying Ordovician belt of the middle Piedmont region, and (2) in Lower Cambrian (?) slates near the western margin of the Piedmont province.

A study of the barite deposits is being made by Mr. Raymond Edmundson, of the graduate school of Cornell University, mainly as a thesis project under the supervision of Professor H. Ries. The barite occurs chiefly in the south-central and southwestern parts of the state, in pre-Cambrian rocks of the Piedmont province and early Paleozoic rocks of the Valley region.

The geology and mineral resources of the Warrenton quadrangle have been surveyed by Dr. A. S. Furcron, of Western Reserve University. This area includes parts of the mountainous belt of metamorphosed Cambrian rocks east of the Blue Ridge, pre-Cambrian rocks of the western Piedmont and the Triassic lowland.

An areal survey of the geology and mineral resources of Giles County, which includes the well-known Narrows area along New River, is being made by Dr. A. L. Mathews, formerly of Oberlin College. The formations are Cambrian to Mississippian, inclusive. Oberlin College has been giving for many years summer field courses in geology in this area under the direction of Professor G. D. Hubbard.

The survey of the geology and mineral resources of the Natural Bridge Special quadrangle has been partly completed by Dr. H. P. Woodward, of Dana College, Newark, N. J., assisted by Mr. Robert Laurence, of the University of Cincinnati. This area lies mainly in the Appalachian Valley and includes a small part of the Blue Ridge. It contains pre-Cambrian to Mississippian rocks, cut by great overthrusts.

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POISONING RODENTS—AND THEN?

IN a recent Associated Press dispatch I was accredited with the unqualified statement that the grasshopper "plague" of the past summer, in parts of the Middle West, was attributable to the virtual elimination of rodents over large areas as a result of concerted poison campaigns. The error which I wish to correct was the failure to quote my original statement that the occurrence of such plagues of insects is one of the results to be expected from rodent elimination. Every biologist, of course, realizes that the factors determining the occurrence of grasshoppers in unwonted numbers are exceedingly complex. Doubtless there are dozens of partial checks rather than a single controlling agent. If there be added an item favorable to their increase, or if there be subtracted one that is unfavorable, there will be just that many more grasshoppers, but no one can predict with reason whether the increase will be one or a thousand per cent.

Certainly the majority of rodents are partially insectivorous. At least some, and presumably all, of the western ground squirrels are very fond indeed of catching and eating grasshoppers. In the treeless parts of the West where insectivorous birds are scarce it is likely that rodents constitute the greatest active check (as contrasted with parasites, disease and adverse meteorological conditions) with which grasshoppers have to contend. But of course this has not been proven, for no extensive investigation has been made to determine what part rodents play in the destruction of harmful insects.

I venture to state that it is universally believed by biologists that as rodents are now being virtually exterminated over large areas by means of poison, their places will be taken by other, and possibly more destructive, forms of life. In a communication to Senator Walcott during 1930 I predicted that the continuance of a federal policy for the elimination of rodents over enormous areas would result in plagues of insects, such as grasshoppers, and the great increase of certain undesirable weeds. In rebuttal, those desirous of arguing to the contrary will at once point out that plagues of grasshoppers have always occurred, from time to time, in many parts of the world. True, of course. It is merely wished to indicate that after the elimination of rodents from an area plagues of grasshoppers will undoubtedly be more frequent and more severe than formerly.

The experience of certain parts of California, poisoned several years ago with distressing thoroughness, now indicates that to the prediction of insect plagues should be added the likelihood of mouse plagues, paradoxical as this may seem. The explanation of this is probably as follows.

Under modern methods of poisoning the mortality of rodents may approach 100 per cent. and certainly reach the point at which it is impossible for local carnivores to make a living, providing of course, all these have not already been poisoned on their own account. At any rate, those remaining must either starve or emigrate, practically to the last individual. On the surface, then, it seems that all rodents and all carnivores are gone, and everything should be lovely. The insidious point, however, is that within every farm house and barn are a few house mice (*Mus*), and in a number of garden patches, not poisoned out of consideration for poultry, is an occasional meadow mouse (*Microtus*) and deer mouse (*Peromyscus*). These, finding the surrounding country untenanted, radiate and, their natural enemies being absent, multiply prodigiously. Unless other factors are unfavorable, in a few years there will be a mouse plague, more damaging to the farmer than if the status quo had been maintained. So, as a sequel to extensive poisoning of rodents (California alone has used over 14,000,000 pounds of poisoned grain and 6,000,000 of carbon bisulphide in the last 10 years) in its present thoroughness we may expect an increase in grasshoppers and more mouse plagues. But rodents do an enormous amount of damage and must be controlled where too destructive. The solution seems particularly clear. Rodents should be rigorously dealt with precisely where damage is being inflicted, and they, with their natural enemies, left alone as completely as practicable on waste land or where little loss is being suffered. Above all, no effort should be made entirely to exterminate rodents over wide areas, even when the process is couched in a less harsh and more soothing term than that of "extermination."

A. BRAZIER HOWELL
JOHNS HOPKINS UNIVERSITY,
SEPTEMBER 25, 1931

TREATMENT FOR POISONING BY "POISON IVY"

THE poison in *Rhus toxicodendron* and other poisonous species of *Rhus* is in the form of an oil. Dissolving the oil and throwing it away before it has time to be much absorbed into the skin is the logical treatment and is completely effective, if used promptly, and is a help even after the skin lesions are well developed. Prepare a hundred or more pinches of absorbent cotton. Use a small saucer of alcohol, 70 per cent. to 95 per cent. strength. Change the alcohol frequently. Dip a small pinch of the cotton in the alcohol and with it sop up the poisonous oil that may be upon the skin and then promptly throw it away. Do not allow any drying of the alcohol. For a small patch of the poison repeat the procedure fifty times or so. At first do not rub, but

merely sop up the poison. After doing this, say, thirty times, rub well with the wet cotton before throwing away each time. Finally rub with the alcohol and cotton very vigorously to get the dissolved poison out of the "pores" of the skin. If small blisters have already formed from the poison the hard rubbing will break them and the contained poison will then be more readily removed.

Do not sop or rub more than a few moments with each bit of cotton, but throw it away almost at once. Allowing the alcohol to dry merely redeposits the poison on the skin and tends also to spread it. Do not use the same swab for repeated dipping. Throw each away at once. One hundred such pinches of cotton is enough to treat, say, two patches of poison each as big as a silver dollar. More extensive poisoning merely calls for more extensive treatment with more swabs.

This treatment is completely effective in all cases in which I have seen it tried promptly. I have not seen it tried in old cases of severe poisoning. I have never known other treatment, potassium permanganate, juice of *Impatiens fulva* or the dozens of commonly recommended "remedies," to do any recognizable good. Logically, washing the hands repeatedly in *many changes* of very strong soapsuds should remove some of the oil and throw it away, but it is seldom, if ever, carried out effectively, and at its best is far less effective than alcohol.

MAYNARD M. METCALF
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OCT. 30, 1931

SCIENTIFIC APPARATUS AND LABORATORY METHODS

TESTING THE REACTION OF DISTILLED WATER

IN talking to various scientific workers, the writer has found that a considerable number of them have the idea that pure distilled water should have a pH of 7 or near that when in contact and equilibrium with the air. Because of this erroneous conception, the writer has been prompted to write the following note of explanation.

Kendall,[1] on the basis of his own investigations and also those of others, concluded that the conductance of carefully purified water is due practically solely to carbonic acid absorbed from the atmosphere. Conductivity and pH measurements of distilled water taken directly from a still may be very misleading and largely meaningless, because under these conditions the content of carbonic acid may vary, depending upon the method of distillation, the temperature at which the water comes from the still and duration of exposure. Unless distillation takes place from an alkaline solution, or other special provisions are made, and the distillate is in all cases properly protected, there is bound to be carbonic acid present in the water. For most purposes, it is folly to go to the trouble of distilling in such a way as to remove the carbonic acid, because it will be quickly absorbed again during ordinary storage or usage of the water. Johnston[2] states that it takes only about ten minutes for unstirred water in an open beaker to come to equilibrium with the carbonic acid of the air. Since most of our experimental work involving the use of distilled water is carried on in a manner which permits contact of water with the air, it should be recognized that the water in these cases dissolves carbonic acid in accordance with the partial pressure of the carbon dioxide in the atmosphere.

On the basis of Kendall's conductivity measurements already mentioned, pure water at a temperature of 25° C. in equilibrium with the atmosphere has a pH of 5.7. A test by Kendall,[3] with the indicator method of water under similar conditions, gave a pH of 5.8. Ordinary and even considerable changes in the temperature of water, causing changes in the amount of carbonic acid dissolved, influence the pH of the water but little, due to a compensation in degree of ionization of the carbonic acid which takes place. Using the indicator method, the writer has found pure water, when in equilibrium with the atmosphere, to have a pH of 5.6 to 5.8. This, as will be noted, checks remarkably well with Kendall's measurements already referred to. Laboratory air sometimes contains enough more carbonic acid to materially change the pH. The pH is, of course, also influenced by various impurities which are present in air in greatly varying amounts. The amounts of ammonia and various acids in laboratory air are often high enough to change profoundly the pH of water exposed to it. Ammonia is often present even in outdoor air in sufficient amount to affect the pH of water. During a rain or snow, this ammonia is largely washed out, and a noticeable change in the pH of water in equilibrium with the air before and after a rain or snow can often be detected with the indicator method to be described. This change is especially marked during periods of infrequent precipitation.

Neutral brom cresol purple is an excellent indicator for testing the pH of distilled water. To make the

[1] J. Kendall, *Jour. Am. Chem. Soc.*, 38: 1480–1497, 1916.

[2] J. Johnston, *Jour. Am. Chem. Soc.*, 38: 947–975, 1916.

[3] J. Kendall, *Jour. Am. Chem. Soc.*, 38: 2460–2466, 1916.

test, place about 5 cc of the water in a test tube and add 5 drops of the 0.04 per cent. indicator solution. Now, pour the water back and forth from one test tube to another for a minute or two, so that the water may come to complete equilibrium with the carbonic acid of the air, and then compare with proper standards. If the water is of good quality and the air is of average outdoor purity, the water should assume a pH of 5.6 to 5.8. If the pH is higher than this, it is a good indication that either the water or laboratory air contains appreciable amounts of ammonia. On continuing to pour back and forth for some time there may be a gradual rise in the pH, due to slow but gradual absorption of ammonia. The water comes to equilibrium with the carbonic acid of the air very much more rapidly than with the ammonia, so that, usually, the factor of ammonia in the air may be ignored. It may, however, be desirable to repeat the test at an open window or door or even entirely outdoors. At times even outdoor air contains sufficient ammonia to appreciably affect the test. The test is so extremely sensitive that it is easily possible to detect the difference in the ammonia content of air before and after a rain or snow.

The test may also be made in the complete absence of carbonic acid and ammonia by bubbling a current of air, purified so as to be free of these gases, through the test solution. The pH of good water under these conditions should approach near 7. For most purposes, however, it suffices to make the test after allowing the water to come to complete equilibrium with the air and recognizing that under these conditions pure distilled water has a pH of 5.6 to 5.8.

It is important to emphasize that pure water has practically no buffer capacity and that minute amounts of impurities may be sufficient to markedly alter the pH of it. In making conductivity tests of water, the same principles should be followed as in pH tests, namely, the water should either be in complete equilibrium with the air, or else carbonic acid and ammonia should be completely removed and excluded during the tests, and the results interpreted accordingly.

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A METHOD OF COPYING KYMOGRAPHIC RECORDS

THE physiologist or pharmacologist who during the course of a year accumulates a hundred yards or so of kymographic records must often wish, especially when he starts to write a paper, that he had in some way secured copies of those parts which are particularly convincing and illustrative, and had filed these under appropriate headings.

It is not always convenient to cut up the original records, and usually it will be found best to file in one place all the tracings made during several hours of experiment on one animal. Yet during that time several different phenomena may have been observed, several different experiments may have been tried, and several drugs may have been administered.

Many years ago it occurred to me that the cheapest method of obtaining a copy would be to make a print on fast bromide paper, using the smoked tracings as a negative. The method is so simple that it does not seem likely that I could have been the first to think of it, but I can not remember ever having heard of any one who used it. If the kymograph paper is well and evenly smoked and not handled overly much by greasy fingers the copy may be more clearcut and better suited for publication than is the original.

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APPARATUS FOR OBSERVATION OF A SMALL OBJECT WHILE FLOODED WITH VARIOUS SOLUTIONS

IN attempts to study the effects of various solutions upon individual nematode ova and coccidia, need has been felt for an apparatus which would allow continuous observation of an individual object before, during and after it was subjected to the action of chemical solutions. Following is a description of such an observation cell which has proved to be very satisfactory for this purpose:

Two small trough-like depressions, (A, A′), about 0.4 mm deep are ground into the surface of an ordinary microscope slide. This is quickly done by holding the surface of the slide against the edge of a small carborundum wheel. Next, a glass tube of approximately 5 mm in diameter is heated and a portion drawn to a diameter of about 0.5 mm, while at the same time the portion of the tube at the constriction is bent to form a right angle. The smaller portion of the tube (B) serves as the inlet to the observation

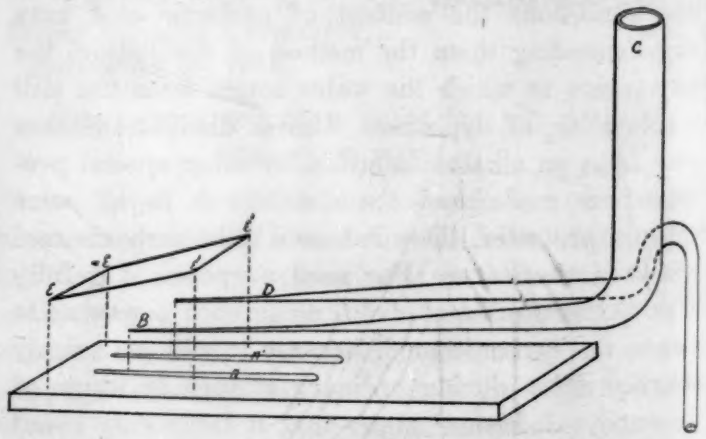

FIG. 1

cell, while the larger portion of the tube (C) becomes the reservoir for the fluid to be introduced into the cell. The smaller portion of the tube is placed in the trough in the slide with the reservoir in a vertical position, and sealed in place by means of De Khotinsky cement or sealing wax. For an outlet to the observation cell, a small glass tube (D) is drawn to approximately 0.5 mm and the opposite end bent to form an inverted U. This tube is placed in the other trough and similarly fastened in place, while the inverted U at the end prevents the liquid from running back along the tube. A cover glass (E, E′) is sealed over the ends of the troughs in such a way as to enclose the ends of both tubes. The side of the cover glass (E′) over the inlet and outlet tubes will be held a small distance above the surface, which will result in a small slant in the cover glass, giving a varying depth to the observation cell.

The material to be studied is introduced into the reservoir, where it drains into the observation cell. With the outlet closed by the finger, air pressure is exerted against the contents of the reservoir (C) with the result that the cover glass is slightly sprung, and the solid objects are forced between the cover glass and the slide where they become trapped with the release of the pressure and the return of the cover glass. Because of the varying depth of the cell it is now possible to select an individual object so located as to be firmly held by the cover glass, but not crushed or distorted. By adding any liquid to the reservoir, a constant bath of the desired liquid can be maintained around the object, while the object remains in focus in a photomicrographic camera or under a microscope. No difficulty has been encountered in maintaining coccidia in focus under either a No. 6 Leitz dry or a 1-7 oil immersion objective.

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A SIMPLE DEVICE FOR HOLDING ULTRAFILTRATION MEMBRANES

THE use of filtration through collodion membranes as a means of purifying biological products and determining the size of colloidal particles is becoming more wide-spread. Many apparatuses have been described to hold the membranes but their construction requires special glass blowing or machine work. The device described here can be prepared in any laboratory.

The filter membrane is held between two glass funnels and is protected from their ground edges by a rubber washer above, and a rubber band stretched over a metal washer below the membrane (Figure 1).

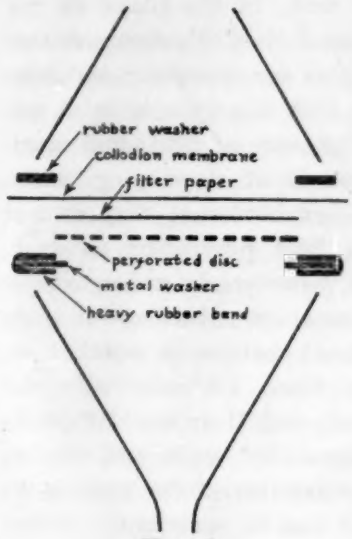

FIG. 1

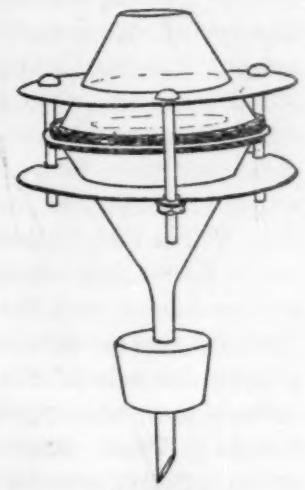

FIG. 2

The metal washer supports a perforated disc upon which is placed ordinary filter paper of the same diameter. When assembled, the top of the rubber band and of the filter paper are in the same plane, to prevent distortion of the membrane under pressure. The filter paper between the collodion membrane and perforated disc serves to increase the effective filtration area.

The funnels are clamped together by two rings of metal or Bakelite as shown in Figure 2. If the filter is to be autoclaved metal rings are advisable. In using metal rings, holes are drilled around their inner edges and a narrow strip of rubber woven through the holes and around the inner edge of the ring, forming a cushion between the funnels and rings.

When autoclaving, the membrane is replaced by filter paper and the apparatus is clamped loosely. After sterilization, the filter paper is replaced by the collodion membrane.

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THE NATIONAL ACADEMY OF SCIENCES. III

The oxygen carriers of the blood in their relation to sex and season: OSCAR RIDDLE. For only two or three species of animals has it been definitely known that hemoglobin and red cells exist in different quantity in the blood of the two sexes, and seasonal changes in these values are very little known. Data of Riddle and Braucher make it clear that in two additional species—ring dove and pigeon—this sex difference is present, that here also these oxygen carriers exist in larger amount in male blood, and that hemoglobin and red-cell values markedly change with season. Riddle, Christman and Benedict have measured the basal metabolism of these

same animals and find that the metabolism also undergoes marked seasonal change. In two species it is thus found that the metabolism, the hemoglobin and the red cells are all decreased to their lowest point in summer and all attain their highest values in the autumn—the season at which these animals were subjected to air of greatest cooling power. All these changes occur in individuals of both sexes. The implantation of male germ glands (testes) into castrated female birds and mammals is known to produce an increase in the hemoglobin or the cell count, or both, in the blood of the castrate; and it has been claimed that this demonstrates that hemoglobin and erythrocytes are secondary sex characters. The new data prove that this conclusion is unsound. The secondary sex characters of birds and mammals represent specific responses of developing parts, areas or tissues to a specific sex hormone; they do not respond to changes in basal heat production as such. Hemoglobin and erythrocytes, however, do undergo their major fluctuations—both increase and reduction—in close correspondence with the seasonal changes in metabolism. The oxygen carriers of the blood fluctuate with the oxygen demands of the tissues, and their sex difference reflects unequal oxygen demands of male and female tissues. These oxygen carriers therefore appear to reflect primary sex difference and to contribute further evidence for the metabolic theory of sex.

The present status of wire-wireless broadcasting on power lines: GEORGE O. SQUIER. As a research student in physics and electrical engineering under Rowland and Duncan in "the golden age" of the Johns Hopkins University over forty years ago, I well remember the discussions which then took place as to the relative merits of direct and alternating current for power transmission. When the alternating current system began to appear the major decision to be made was to select the frequency. Little did the small group which formed a part of the "Big Eight" realize that when the number 60 cycles per second was selected after wide discussion throughout the small engineering profession in the United States at that time, at a single stroke a step was taken which has determined the design of the whole vast power-wire pattern which to-day links this country from ocean to ocean, and from the Great Lakes to the Gulf of Mexico. To-day this aristocratic number 60 throbs incessantly throughout a vast territory extending from the remote farmer's cottage to the heights of the Empire State Building in New York City. This national pendulum ticks with a regularity and accuracy which permit us to live in a split-second world which it has created. There was another key decision made at that time whose history is not so easy to determine. Some unknown mechanic or electrician casually decided to construct the standard lamp socket of the diameter of one inch, and to employ the basic principle of the screw for reliable electrical contact. To-day the number of these standard sockets in use in the United States is roughly estimated as $50 \cdot 10^7$. On September 18, 1910, for the first time, two separate telephone conversations were carried on over a single "twisted pair" wire telephone circuit between the Signal Corps Laboratory at the National Bureau of Standards in Washington, D. C., and the small laboratory at 1710 Pennsylvania Avenue. Then was born the new art of wire-wireless communication engineering. At the annual meeting of this academy in April of the present year, I brought to the attention of the academy a new development of wire-wireless called the monophone, or one-way telephone, for broadcasting and pointed out at that meeting the astonishing fact that our telephone plant, which has now reached 80 million miles of wire, was operating only about 18 minutes a day or at an "overall inefficiency" of some 98 per cent. The magazines recently announced that these idle wire facilities are being reserved for a two-way long distance television service as supplementary to the point-to-point service on the regular telephone plant. At 4 p. m. on March 24, 1922, in the presence of the Associated Press and a group of radio engineers, occurred the first demonstration of wire-wireless broadcasting of programs on the regular standard electric light circuit in the office of the chief signal officer of the army, in the Munitions Building, across the street from the National Academy of Sciences Building in Washington. To-day after nine years I have to report a practical development extending continuously throughout this period at a cost of some three millions of dollars where at present a staff of 75 men are employed in the laboratory at Ampere, New Jersey. Superimposed upon the 60 cycle power transmission plant without interference, is a 13 kilocycle carrier current which is stepped up in multiples of the lucky number 13 to deliver three separate programs simultaneously into the homes of subscribers from the standard light socket on frequencies of 26, 39 and 52 kilocycles per second. The complete equipment designed, manufactured and tested for 270,000 homes is now ready for shipment to Cleveland, Ohio.

A critical study of the magneto-optic method of analysis: JACOB PAPISH and A. C. SHUMAN (introduced by W. D. Bancroft). The magneto-optic method of analysis was applied to the identification of a number of chemical elements. The method was found inadequate in the case of mixtures, and the authors call attention to the fact that further study may throw light on the cause of "minima" observed when solutions are examined by this method.

The Zeeman effect in the $^2\Sigma$, $^2\Sigma$ band spectrum of calcium hydride: WILLIAM W. WATSON (introduced by F. Schlesinger). This paper deals with the effect of a magnetic field on the energy levels of the type known as $^2\Sigma$ for diatomic molecules, with the object of learning more about the dynamics of such molecular states. The $^2\Sigma$, $^2\Sigma$ band spectrum of calcium hydride in the region of 6350A serves the best for this investigation because of the record size of the doubling of the energy levels involved, the wide spacing of its lines and its position in the spectrum. The spectrum has been photographed at various strengths of the magnetic field up to 30,000 gauss, and the resulting measurements compared with the patterns of the spectral lines as pre-

dicted by existing ideas of the dynamical behavior of molecules in $^2\Sigma$ states. The results show that the magnetic interaction is largely that of an electron spin of ½ a Bohr unit and the external field, superposed on the internal coupling of electron spin to the rotational axis of the molecule. Marked asymmetries in the patterns appear for lines arising from the higher rotational levels of the molecule, however, which can be attributed to the presence of a sizable component of electronic orbital angular momentum along the axis of rotation. Data on the relative intensities of the different kinds of energy transitions in the presence of the magnetic field are also presented.

Imaginary geometry and relativity: EDWARD KASNER.

Applications of relativistic thermodynamics to cosmological problems: RICHARD C. TOLMAN. For several years the author has been endeavoring to develop the principles for an extension of thermodynamics to general relativity, which would make it possible to treat the thermodynamic behavior of systems under circumstances where the gravitational field can not be neglected. The purpose of the present paper is to give a brief summary of the results that have been obtained by applying the new principles to several problems which might be of interest for cosmology. Some of these results have previously been published. The principles were first applied to systems in static thermodynamic equilibrium. In the case of a non-uniform static gravitational field, it was shown that the conditions for thermal equilibrium would necessitate a definite temperature gradient in order to prevent the flow of heat from regions of higher to those of lower gravitational potential. And, both in the gravitational field of a spherical distribution of fluid and in that of a static Einstein universe, it was shown that the concentration of matter in equilibrium with radiation, assuming their interconvertibility, would be the same as in flat space-time. The principles were then applied to non-static systems in which reversible processes take place. Possibilities were found which do not exist in the classical thermodynamics for processes to take place at a finite rate and nevertheless reversibly without increase in entropy. It was shown that several different models of the universe could expand or contract at a finite rate and yet reversibly without increase in entropy; and a number of phenomena were found in the case of reversibly expanding universes, such as the outward flow of radiation, which have ordinarily been interpreted as irreversible. The possibilities for periodic expansion and contraction of the models was also studied, and it was shown that although no strictly periodic solutions of the equations of motion are possible, nevertheless, quasi-periodic motions are allowable which would in effect give a series of identical expansions and contractions without increase in entropy. Finally, the new principles have been applied to non-static systems in which irreversible processes take place. Owing to the well-known fact that the principle of the conservation of energy does not hold in relativistic mechanics in the same simple form as in classical mechanics, it is found that the possible increases in entropy which accompany the occurrence of irreversible processes in an isolated system are not subject to a limitation such as imposed in the classical thermodynamics by a fixed constant value for the energy of the system. Indeed, models of the universe can be conceived which would undergo a succession of irreversible expansions and contractions without the entropy reaching an unsurpassable maximum where further change would be impossible.

The equation of state of real gases and its quantum dynamical correction: HENRY MARGENAU (introduced by F. Schlesinger). The equation of state of a gas is a mathematical expression of the manner in which the pressure changes when temperature and volume are varied. Its usual derivation is based upon the picture according to which each molecule may move freely in space and attracts every other molecule with a force depending on the distance of separation. There is no restriction upon the velocity which any given molecule may possess. By quantum dynamics it can be shown that, under the action of attractive forces of the actually existing type, pairs of molecules may, under certain conditions, form a loose combination, different from a chemical bond. When two structures are bound together in this way they vibrate in a definite manner with roughly calculable frequencies, which make it impossible for the individuals to have any velocity whatever. Hence, in the calculation of the equation of state, these impossible velocities must be excluded. In the present paper this calculation is carried through. The result does not differ appreciably from the usual one if the gas is considered at high temperatures, but at low temperatures a considerable difference arises. While it is difficult at present to make accurate numerical comparisons between the theoretical formula and empirical observations, the corrections which this theory imposes are qualitatively in line with the available experimental evidence.

A new photographic map of the Moon: F. E. WRIGHT and F. G. PEASE. In selenographic literature the question of possible changes in the surface features of the Moon is under constant discussion and the answer is sought in a comparison of early, with more recent, maps and descriptions. No satisfactory decision has been reached because all maps heretofore produced have been drawn by hand and these are subject to personal factors difficult to evaluate. The present series of maps seeks to eliminate the personal factor and to produce, with the best means at present available, a series of photographic maps in which the photographs taken with the 100-inch Hooker telescope at Mt. Wilson Observatory are transformed by a special method of projection, so that in each photograph the Moon is viewed along the standard line of sight normal to the plane of mean libration. The principle of transformation is similar to that used in airplane mapping; but the method adopted is quite different because the whole

lunar hemisphere is involved and not simply the transformation from one plane surface to another.

Metabolic activity of the bacterial cell: C.-E. A. WINSLOW and HAROLD H. WALKER (introduced by G. P. Clinton). Bacteria of the colon group have been cultivated in vessels continuously aerated during the course of the experiment with air which had been freed from carbon dioxide and ammonia. The effect of the aeration procedure on growth was determined and average curves plotted for the population cycle. Specific growth phases of short duration were selected at various points on the population cycle and simultaneous determinations made, at the beginning and end of each phase, of bacterial increase, reaction change in the medium, sugar consumption, change in CO_2 and NH_3 content of the medium and aeratable CO_2 and NH_3 collected by the air train during such period. This method of cultivating bacteria in a continuously aerated medium gives a more normal picture of the life cycle of a bacterial population than that obtained in ordinary techniques which involve the rapid inhibition of the organisms by their own waste products. Three basic media were used, 1 per cent. peptone solution, a solution containing ½ per cent. peptone and ½ per cent. lactose and a simple synthetic medium (the Dolloff medium) containing ammonium tartrate as a source of nitrogen and lactose as a source of energy. There is a definite life cycle for each medium, involving (a) a preliminary lag with little change in population, (b) a logarithmic increase in numbers and (c) a period of relative stability. The process of aeration, it is interesting to note, is highly favorable to development in the lactose and peptone media through the removal of toxic waste products, but is distinctly inhibitory in the simple synthetic medium, presumably through the removal of growth-stimulating substances. The principal results to date appear to be the demonstration that the production of both carbon dioxide and ammonia-nitrogen per cell increases enormously during the period of active multiplication or logarithmic increase. Late in the preliminary lag period and in the phase of logarithmic increase the culture produced 40–100 x 10^{-11} milligrams of CO_2 per cell per hour, while in the later period of stability the figure fell to 1–2 x 10^{-11}. For ammonia-nitrogen, the rate of production during the late lag phase was about 15 x 10^{-11} mgm per cell per hour and for the phase of logarithmic increase, 4 x 10^{-11} while for the phase of ultimate stability ammonia production fell to 0.2 x 10^{-11}. During the lag phase the ratio of carbon dioxide to ammonia-nitrogen is about 4, during the logarithmic phase over 10 and during the period of stability when growth balances death about 6, expressed in relative weights of the gases yielded. If we compare the metabolism of the cells during the period of lag and of logarithmic increase with their metabolism during stability of population we find that CO_2 production is increased thirty-fold and $NH_{3\text{-}N}$ production 20–70 fold. The ammonia formed may of course be largely derived from extracellular decomposition of pepton. The increase of CO_2 production, however, would seem to be a measure of increased metabolism due to the physiological condition of the actively multiplying cells.

The physical and behavioral development of a female chimpanzee during the first year of life: C. F. JACOBSEN (introduced by R. M. Yerkes).

Some observations of the behavior of chimpanzees in a native habitat: H. W. NISSEN (introduced by R. M. Yerkes).

Reinforcement and inhibition of eyelid reflexes to light and sound: ERNEST R. HILGARD (introduced by R. Dodge). A faint stimulus, itself eliciting only minimal reflex responses, may greatly exaggerate or depress the responses to a more adequate stimulus which follows it. This is demonstrated in certain experiments on the human eyelid reflex, in which a faint light preceded a loud sound. The light alone evoked winking responses averaging 4 mm in extent, while the sound evoked winking responses averaging 20 mm. When the light preceded the sound by appropriate intervals (of from 0 to .050 sec.) the response to the sound was increased to a maximum average extent of 31 mm, an increase of 11 mm above the normal. This increase of 11 mm is due to the prior occurrence of a light which alone evoked a response of but 4 mm. On the other hand, the response to sound may be greatly decreased in extent if the light precedes the sound by a slightly lengthened time interval (interval of .075 sec. or greater). This inhibitory effect is even more pronounced than the reinforcement just described. The reaction to sound may fall as low as 1 mm in extent from the normal of 20 mm, a drop of 19 mm. All the eyelid responses were recorded by the photographic method of Dodge, using his pendulum photochronograph. The experiments point to the importance of the faint stimuli playing upon the organism and creating the dynamic background into which a new stimulus is received. The responses to the new stimulus will be greatly modified by immediately preceding events. The reversal of effect from reinforcement to inhibition with fine changes in time relations bears importantly on the theory of conditioned reflexes widely used by psychologists in explanation of habit formation.

Some psychopathological aspects of the personality of the scientist: DR. EUGEN KAHN (introduced by Dr. Raymond Dodge). Every personality is a complex combination of physical, impulse, temperament, instinct, intelligence and character factors. The individual combination of these factors is decisive for the personalities' attitudes. Evidently all these factors must be present, to some degree, in the scientific personality. It may be desirable to consider three special attitudes which seem to be outstanding in the personality of the scientist: Ambitendence, anancasm and paranoia.